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A METHOD OF IDENTIFICATION AND DESCRIPTION OF SUGAR CANE VARIETIES, AND ITS APPLICATION TO TYPES GROWN IN PORTO RICO.

By H. B. Cowgill, Plant Breeder, Insular Experiment Station.

The number of varieties of sugar cane (*Saccharum officinarum*) is increasing rapidly,* and for this reason it is desirable to have a method of describing and identifying them. In some cases the points of difference are easily seen, but usually this is not so. This may be due to any of the following reasons: first, that there is a wide range of variation within the varieties, so that, as a consequence, the type is not represented in a single stalk, or in a single plant; second, that a large number of varieties tends to make the differences between some of them very slight; and third, that the differences are quantitative variations of characters common to all, and not the addition of definite new characters. The distinguishing marks are not always found on all the stalks. The type is in many cases difficult to determine, and although two varieties grown side by side may be seen to be distinctly different, it is not always easy to state wherein the differences lie.

Cane varieties vary widely in economic characters as well as in appearance. These characters are yield of cane, sugar content, milling quality, resistence to diseases, resistence to unfavorable conditions for growth, and so forth. Some varieties are much better suited to certain localities than others, and in Porto Rico it may be said that the four kinds of cane extensively cultivated are most commonly grown in more or less well-marked regions. This seems to be largely due to soil and climatic conditions, although it is difficult to state definitely, in every case, the exact factors which control their distribution.

THE PARTS OF THE SUGAR-CANE PLANT.

The sugar cane belongs to the grass family, or *Gramineae*, subfamily *Poacoideae*, tribe *Andropogoneae*, and genus *Saccharum*. The stems are unbranched and solid. The leaves are alternate and are

* The increase in the number of varieties is a result of breeding, conducted for the purpose of securing superior kinds. This is being done in practically all cane-producing countries. It was commenced in Java in 1887 and in the British West Indies in 1888, and was taken up on account of the advance made by the sugar beet industry in competition, and an apparent deterioration of the standard varieties of cane.

deciduous, with the apparent exception of certain varieties whose leaves adhere to the stalk after they have become dry. There is a bud at each node at the place of attachment of the leaf-sheath. The inflorescence is a many-flowered panicle. The spiklets are one-flowered, in pairs on an articulate rachis and are enveloped in long, silky hairs.

The cane, in common with many other grasses, is propagated by the development of rhizomes from underground buds, by the growth of buds of the stems when they come in contact with the moist soil, and by means of true seed. A stool of cane may be large or small, and may reproduce itself by rhizomes a greater or fewer number of years, depending on the tenacity of the variety and fertility of the soil.

The most important differences for purposes of identification are variations in the parts of the stalk. Differences in floral parts cannot well be used, because many varieties do not blossom, and because the period of flowering lasts only a few weeks. The stalk is the part of commercial importance and it is often desired to identify varieties by the stalk alone. However, the characters of the leaf are sometimes distinctive and may be used in identifying standing cane. More or less distinct differences are seen in the two parts of the leaf, the leaf-blade and the leaf-sheath.

The Stalk.—Stalks of different ages are usually found in a single stool, due to the fact that the buds from which they develop do not all start at the same time.* As stalks change in appearance towards maturity, neither very young stalks, nor those completely mature are most typical of a variety. The appearance of the stalk is also affected by its state of vigor, due to soil or climatic conditions. For example, a prolonged drought causes the internodes to grow short, whereas favorable moisture conditions produce long internodes and larger and plumper buds. A stalk of cane is composed of nodes, internodes, and buds, and these parts show characteristics which aid in distinguishing one variety from another.

The Internode varies in average length, diameter, and shape, being often nearly round, but frequently more or less flattened, sometimes tumid, and sometimes constricted, or larger on one side or at one end than at the other. In many varieties the internodes are more or less distinctly furrowed on one side, the furrow varying in length, depth, and width.

* The cane has a tendency to mature most rapidly in the fall and winter. The blossoming period is in November and December, and after blooming it comes to maturity more quickly, unless the occurrence of heavy rains retards ripening; but new stalks may appear at different times during the growth of the cane, and therefore the state of maturity of any stalk depends largely on its age.

The node varies mainly in form and size. The leaf-scar varies more or less in shape and prominence, and it is sometimes beset with short, stiff hairs. It divides the node into two parts; the part above the leaf-scar consisting of a band or ring, which varies in width and in form, and has many rudimentary roots, there being differences in the number, arrangement, and general appearance of these roots. The portion of the node below the leaf-scar is a more or less depressed ring extending around the stalk.

The Bud.—This usually shows greater varietal differences than the other parts of the cane. Buds vary in length, width, prominence, and shape. The outside scales show differences in shape, size, and texture; their outer edges form a flattened margin which varies in width and in form. Buds are more or less acute-pointed and sometimes bearded, or hairy.

The general characters of the stalk are its color, length, diameter, shape, and amount of glaucousness, or "bloom."

The Foliage, as a whole, varies in color and in relative abundance. The leaf-blade varies in length, width, shape, position, and color. The leaf-sheath shows differences mainly in shape, color, vestiture and tenacity to the stalk. At the place of union of sheath and leaf there are often characteristic differences. The edges of the sheath, just below the point of union of sheath and leaf, have appendages or "auricles," which vary in size and shape. The surface and edges of leaf and leaf-sheath also vary in amount and character of their vestiture.

TERMS USED IN DESCRIBING CANE VARIETIES.

It is necessary to take into consideration variations which exist within the varieties in making descriptions, as it is not always possible to find distinguishing, and at the same time plainly evident marks, so that usually the type must be gotten from several canes of the variety. Average canes should be described, the extreme variant forms being noted but given minor consideration. The most marked characteristics and their range of variability can be remembered for purposes of identification.

Special terms are used in this paper to describe various parts of the cane, as follows. The habit of the plant is described as erect, inclining, reclining, recumbent, or spreading. The term spreading indicates a tendency of the clump to recline in all directions from its center. The term staggered, as applied to the internodes, means alternating in their main axes, from forward to backward and vice versa. The term tumid means enlarged or swollen. "Shoulder".

is applied to a sudden increase in size, or an offset. The furrow is a channel sometimes extending up from the point of attachment of the bud, for all, or a part, of the length of the internode. Barbate signifies bearing hairs, or bristles, in a tuft, like a beard. Barbellate means beset with short, stiff hairs. The term margin is applied to the flattened edge of the bud, formed by the edges of the outside scales. Lobes are expanded areas of the lower part of the margin. Buds are described as prominent when they project from the stalk, depressed when the point is turned down upon the stalk, and appressed when flattened against it. The throat of the leaf-sheath is the region adjacent to the place where it joins the blade. The ligula is a membranaceous appendage of the leaf-sheath, extending up from the point of union of the sheath and blade. The auricles are lateral appendages of the leaf-sheath, just below the point of union with the leaf. Setae are hairs, or bristles, usually rigid and sharp pointed, but sometimes soft, which are often, but not always, found on the back of the leaf-sheath. The term vestiture applies to the setae or hairs occurring on the leaf-sheath or at its throat.

DESCRIPTION OF VARIETIES.

Following are descriptions of some of the cane varieties which have been under trial at this Station. The purpose is to show the application of a method used in identifying and describing varieties, as well as to give descriptions of some of the most important kinds in Porto Rico. The names by which they are known here may be different, in some cases, from their original names, as many of them came to us indirectly. The descriptions apply to the canes known by these names on this Island.

Otaheite.—Habit erect to reclining. Length medium. Diameter medium to large. Shape of stalk curved. Color greenish yellow, a glaucous ring on the lower half of the node. Internodes varying much in shape; typically rather tumid, but sometimes with sides straight, and when tumid most so on the side opposite to the one which bears the bud; somewhat flattened, usually more or less staggered; furrows medium to shallow. Nodes medium size, longest on the bud side; leaf-scar set more or less oblique and projecting somewhat prominently from beneath the bud; the portion above the leaf-scar about the same diameter as the internode above, except when the latter is tumid; the depressed ring, forming the portion below shallow; rudimentary roots in two or three rows. Buds typically sub-eliptical to ovate in outline but varying in size and in rela-

tive length and width; apex semi-elliptical to acute; margin narrow and conforming to the shape of the bud; no prominent lobes; sometimes hairy on the sides and bearded near the apex. Foliage medium abundant, light green in color. Leaf of medium width and length, tapering into a long and fine point. Leaf-sheath rather flattened at the throat; auricles medium to large, often long and acute-pointed on one or both sides of the stalk; ligula medium length, with the upper edge depressed in the center. Vestiture of leaf-sheath many setae which are stiff and not closely appressed. Vestiture of throat of sheath a small amount of medium fine hairs on or adjacent to the auricles. Most important distinguishing characters shape of the buds and of the internodes.

Rayada.*—Habit erect to recumbent. Length medium. Diameter variable but averaging about medium. Shape of stalk more or less curved. Color longitudinally striped with reddish-purple and light green, the stripes varying in width with different stalks and different internodes; more or less glaucous. Internodes medium to short, slightly flattened, typically plump, and more or less tumid on the side opposite the one on which the bud occurs, sometimes straight-sided, often staggered; furrow medium to shallow but usually broad. Nodes medium size; the portion above the leaf-scar often a little smaller in circumference than the internode, and usually a slightly projecting ring at the dividing line of the node and the internode above; the depressed ring forming the portion below typically deep, especially below the bud; the leaf-scar projecting from beneath the bud; rudimentary roots in about three rows. Buds varying in size and in relative length and width, typically broadly ovate-acuminate to broadly ovate in outline, sometimes obtuse-angular; usually plump; point rounded to medium acute; margin medium to wide, typically with medium to large lobes on the sides, often bearded at the point. Foliage abundant, the dry leaves also retained far down on the stalk, medium green in color. Leaf medium width, medium length, tapering into a long point. Leaf-sheath flattened laterally; auricles medium to small, sometimes pointed on one side of the stalk; ligula medium length, with the upper edge rounded in outline. Vestiture of leaf-sheath a few short setae in a line on the back. Vestiture of throat of sheath medium coarse hairs on, or adjacent to, the auricles and on the edges of the base of the leaf, also sometimes pubescent on the surface of the base of the leaf. Most important distinguishing characters color and the shape of the buds.

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* This is the striped cane which is widely cultivated on this Island. It is apparently closely related to the Crystallina variety.

Crystallina.—Habit erect to recumbent. Diameter medium. Shape of stalk usually curved. Color varying from shades of greenish-red to straw color, sometimes tinted with violet or purple; very glaucous. Internodes varying in length, but averaging about medium; varying also in shape, often tumid on the side opposite the one on which the bud occurs, typically plump, and flattened laterally; furrow medium depth. Nodes medium size, typically larger in the upper part; the lower portion a distinctly depressed ring, which is deepest below the bud; the leaf-scar projecting prominently from beneath the bud, but adhering closely to the stalk on the opposite side; rudimentary roots in three or four rows. Buds varying in length and width, usually plump; typically broadly ovate-acuminate to triangular, with a margin medium to wide; sometimes broadly ovate or semi-elliptical; lobes typically distinct; may or may not start to expand on the standing cane. Foliage abundant, some of the dry leaves also adhere to the stalk, medium green in color. Leaf medium width, medium length, tapering into a long, acute point. Leaf sheath somewhat flattened laterally at the throat; auricles medium size; ligula medium length, with the upper edge rounded in outline, or occasionally slightly depressed in the center. Vestiture of leaf sheath a few setae in a line on the back. Vestiture of throat of sheath medium coarse hairs on auricles, adjacent edges and face of the leaf, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters color and the form of the internodes and buds.

Cavengerie.—Habit erect to reclining. Length medium. Diameter medium. Shape of stalk more or less curved. Color dark wine to greenish-red, with faint greenish to bronze longitudinal stripes; the lower part of the node more or less glaucous. Internodes nearly round in cross-section, medium to long, typically almost straight-sided, but sometimes inclined to be tumid in the lower half; often more or less staggered; furrow very shallow. Nodes small; the leaf-scar often oblique, usually a slightly prominent ring at the upper limit of the node; the depressed ring forming the portion of the node below narrow and shallow; two, to occasionally three, rows of rudimentary roots. Buds usually dark in color, typically plump and very short, with the margin scarcely perceptible, and the point round and obtuse, set in a cavity of the stalk; but sometimes longer and the point more acute. Foliage abundant, medium green in color. Leaf medium width, medium to short, semi-erect, tapering to a fine point rather abruptly. Leaf-sheath slightly flattened at the throat; color reddish green, striped with light, longitudinal stripes; auricles small; ligula medium to narrow, turned in toward the stalk, and

with the upper edge depressed in the center. Vestiture of leaf-sheath many sharp, stiff setae. Vestiture of throat of sheath straight, rather short hairs on the auricles, adjacent edges of the leaf and leaf-sheath, and sometimes on the face of the base of the leaf. Most important distinguishing characters color, striped leaf-sheath, and form of the buds.

Yellow Caledonia.—Habit erect. Length long. Diameter above medium. Shape of stalk straight. Color greenish-yellow, tinged with red on the upper internodes and where exposed to the sun; with fine, dark-colored cracks in the epidermis; more or less glaucous on the lower part of the node. Internodes long and quite uniform; typically straight-sided, but sometimes slightly constricted and sometimes slightly sub-conical; no furrow. Nodes rather large; the portion above the leaf-scar long and about the same diameter as the internodes; about four rows of rudimentary roots; leaf-scar projecting prominently from beneath the bud. Buds usually small but uniform, about as broad as long, typically ovate to sub-elliptical in outline, plump and with a margin narrow but uniform as to width, and following the shape of the bud; scales of fine texture; bearded at the tip and sometimes pubescent on the sides. Foliage abundant, green leaves inclined to adhere to the stalk rather far down, but the dry leaves are shed; medium dark in color. Leaf broad, long, tapering medium abruptly into a point. Leaf-sheath large in circumference at the throat, color light green with sometimes a pinkish tinge; auricles small; ligula medium length, with the upper edge depressed in the center. Vestiture of leaf-sheath a few setae in a line on the back. Vestiture of throat of sheath short hairs on the auricles, adjacent edges and face of the base of the leaf, and sometimes back of the ligula; also sometimes finely pubescent on the face of the base of the leaf. Most important distinguishing characters color, cracks in the epidermis, and form of the internodes.

B–347.—Habit erect to reclining. Length medium to long. Diameter medium to large. Shape of the stalk usually straight. Color yellowish-green, with a tinge of red on the upper internodes; more or less glaucous; marked with irregular, light-colored spots, apparently caused by a loss of the cuticle. Internodes slightly flattened, medium length, usually staggered; sides sometimes straight but usually more or less tumid, mainly on the side opposite the one on which the bud grows. Nodes medium to large; the leaf-scar projecting out a little on all sides; above the leaf-scar often a little smaller than the portion of the internode just above it; rudimentary roots two to five rows. Buds typically long in comparison to width,

ovate to oval in outline, with the point extended flat against the cane; margin narrow, the point of the margin typically long and semi-elliptical in shape. Foliage medium in amount, medium green in color. Leaf of medium width, medium to short, sub-erect, edges having a tendency to curl. Leaf-sheath flattened laterally at the throat, glaucous; auricles medium size; ligula medium to short, with the upper edge usually depressed in the center. Vestiture of leaf-sheath many long and rather soft setae. Vestiture of throat of sheath medium abundant, long, rather soft hairs on the auricles, and adjacent edges and face of the leaf, and sometimes behind the ligula; also sometimes pubescent on the face of the base of the leaf. Most important distinguishing characters the form of the buds, curling of the leaf, and light colored spots on the internodes.

B–3412.—Habit erect to inclining. Length long. Diameter medium to small. Shape of stalk straight to slightly curved. Color greenish-red but varying in redness with amount of sun-exposure; a glaucous ring on the node below the leaf-scar. Internodes medium to long, nearly round in cross-section, typically straight or slightly depressed on the side above the bud but tumid on the opposite side; furrow just perceptible. Nodes medium size, typically larger above the leaf-scar than below it, slightly longer on the side of the bud; about three rows of rudimentary roots. Buds typically having started to expand, projecting through the outer scales and standing out from the stalk; before starting typically semi-elliptical to broadly ovate in outline, plump, adhering closely to the stalk, having a margin of medium width, lobes inconspicuous. Foliage rather less than medium, medium to dark in color. Leaf narrow, medium length, tapering into a long point. Leaf-sheath nearly round at the throat, often reddish in color; auricles medium size; ligula medium to short, with the upper edge rounded in outline. Vestiture of leaf-sheath many medium stiff setae. Vestiture of throat of sheath medium coarse hairs on the auricles and sometimes extending onto the edges and surface of the base of the leaf. Most important distinguishing characters color and the shape of the buds and the internodes.

B–109.—Habit erect to inclining. Length medium to long. Diameter medium to large. Shape of stalk more or less curved. Color greenish-yellow, with a glaucous ring below the leaf-scar. Internodes medium length, nearly round in cross-section; typically nearly straight-sided, but sometimes slightly staggered, and then slightly tumid on the side opposite the one on which the bud occurs; furrow not perceptible, or very shallow. Nodes medium size; above the leaf-

scar about as large or larger than the internodes, usually a prominent ring at the upper limit of the node; two to three rows of rudimentary roots. Buds typically variable in size and shape and more or less triangular in shape, usually short for their width, sometimes having the appearance of being five-sided; margin typically narrow and uniform in width with the sides of the bud, edges either straight, curved or irregular; lobes small or none. Foliage abundant; retained well down on the stalk, including some of the dry leaves; medium to dark in color. Leaf medium to broad, medium length, tapering into an acute point of medium length. Leaf-sheath almost round at throat, glaucous; auricles small, sometimes long-pointed on one side of the stalk; ligula medium to short, with upper edge rounded in outline. Vestiture of leaf-sheath a few setae which are short and soft. Vestiture of throat of sheath medium coarse hairs on the auricles, edges and surface of base of the leaf, and sometimes a few extending to the area behind the ligula. Most important distinguishing characters color and the form of the internodes and buds.

B–208.—Habit inclining to reclining. Length medium to short. Diameter medium to large. Shape of the stalk usually curved. Color medium green, more or less glaucous. Internodes nearly round in cross-section, typically short and tumid, and with a prominent shoulder on the side opposite the one on which the bud occurs; furrow very shallow. Nodes small; the portion above the leaf-scar a little longer, and larger in circumference than that below; the depressed ring forming the portion below the leaf-scar medium depth but narrow, deepest below the bud. Two or three rows of rudimentary roots. Buds typically having started through the scales and projecting out from the stalk in a globoid to conical point; before starting short and swollen; when very young typically flat, very broad and ovate-cuspidate in outline, with the margin extending across the top or rather than on the sides; lobes typically well-marked. Foliage medium in amount, rather dark in color. Leaf medium to short, broad, growing semi-erect, tapering medium abruptly into a point. Leaf-sheath broad, almost round at the throat, light green to reddish-green in color; auricles medium to small; ligula medium length, with the upper edge slightly depressed in the center. Vestiture of leaf-sheath many long, medium stiff setae, not closely appressed. Vestiture of throat of sheath medium soft hairs on the auricles and edges of the base of the leaf, and more or less on the adjacent area of the face of the leaf. Most important distinguishing characters form of the internodes and buds.

B–6450.—Habit reclining. Length medium. Diameter medium.

Shape of stalk more or less curved. Color green when young, yellowish-green when mature; the surface is smooth and sometimes glossy on the young stalks but when old it often contains fine cracks; usually glaucous on the lower portion of the node. Internodes medium length; typically variable in shape, but tumid on the side opposite the bud and more or less staggered; furrow broad and shallow, deepest underneath the bud. Nodes medium length; the depressed ring forming the portion below the leaf-scar medium width and depth, deepest immediately below the bud; rudimentary roots far apart, white, in two to four rows. Buds medium size, typically ovate to triangular in outline, rather flat when young; margin usually narrow and conforming to the shape of the bud; sometimes pubescent at the base. Foliage abundant, medium green in color. Leaf of medium length and width, tapering into a medium long point. Leaf-sheath flattened laterally at the throat; auricles medium to large, often a little more pointed on one side of the stalk than the other; ligula medium to long, with the upper edge rounded to obtuse-pointed in the center. Vestiture of leaf-sheath rather fine setae. Vestiture of throat of sheath medium soft hairs on the auricles and edges of the base of the leaf, and sometimes a few in adjacent area behind the ligula. Most important distinguishing characters color and shape of the buds and the internodes.

B–7245.—Habit erect. Length medium. Diameter medium to large. Shape of stalk straight. Color green to yellowish-green, some of the upper internodes slightly reddened; the lower portion of the node glaucous. Internodes medium to long, nearly round in cross-section, almost straight-sided, but the shorter internodes are tumid and the longer ones typically slightly constricted in the lower half on the bud side, or all around, making the upper half the largest in circumference; furrow broad but usually shallow. Nodes medium to large, the portion above the leaf-scar short on the side opposite the bud; typically smaller in diameter above than below; the upper portion increasing in size from below upward, and forming a prominant ring at the upper extremity of the node; the leaf-scar and the depressed ring forming the portion below it oblique; two to three rows of rudimentary roots, which are conspicuous. Buds varying in size, generally adhering closely to the stalk, usually about as broad as long; typically ovate to broadly ovate in outline, with the point rounded and the margin medium to narrow; sometimes bearded at the apex. Foliage abundant, medium green in color. Leaf medium to wide but variable, medium length, tapering into a medium to long point. Leaf-sheath distinctly flattened laterally at the throat; auri-

cles medium to large, those on one side of the stalk sometimes acute-pointed, and on the young sheaths, overlapped by the others; ligula medium to short, with the upper edge sub-elliptical, to obtuse-pointed in the center. Vestiture of leaf-sheath very long, sharp and prominent setae. Vestiture of throat of sheath medium soft hairs on the auricles, edges of the leaf, and a few back of the ligula. Most important distinguishing characters the shape and size of the internodes and the buds.

B–1809.—Habit erect. Length long. Diameter large. Shape of stalk straight. Color medium green when young, but becoming yellowish-green with age; a glaucous ring on the node below the leaf-scar, which becomes dark with the aging of the stalk. Internodes medium to long, flattened; typically nearly straight-sided or largest in diameter just above the node, where there is a prominent ring, and on the side opposite the bud a shoulder; furrow broad and rather deep, but narrower and shallower toward the top of the internodes. Nodes rather large; typically smaller below the leaf-scar than above, and increasing in size above until the lower limit of the internode is reached; two or three rows of rudimentary roots; the depressed ring forming the portion below the leaf-scar shallow on the side opposite the bud but deeper immediately below it. Buds typically long and more or less triangular in shape with the point either broad or acute; but sometimes about as broad as long, more or less ovate and acute-pointed; adhering rather closely to the stalk; often increasing in length on the standing stalk, but not usually projecting much through the scales; margin medium to narrow, and conforming to the shape of the bud, or forming small lobes at the sides; usually bearded near the point. Foliage abundant, medium green in color, many dry leaves also retained. Leaf medium to broad, medium length, erect growing. Leaf-sheath somewhat flattened at the throat, glaucous; auricles medium to small; ligula medium length, with the upper edge usually depressed in the center. Vestiture of leaf-sheath medium stiff setae on the back. Vestiture of throat of sheath medium long hairs on the auricles and edges of the base of the leaf, and sometimes a few on the adjacent areas of the face of the base of the leaf; sometimes slightly pubescent on the face of the base of the leaf. Most important distinguishing characters the shape and size of internodes, buds, and leaves.

B–3859.—Habit inclining. Length medium. Diameter medium. Shape of stalk more or less curved. Color wine to greenish-wine; a glaucous ring on the lower half of the node. Internodes medium length, nearly round in cross-section, varying in shape with different

stalks, sometimes straight-sided, but typically tumid in the lower part, especially on the side opposite the bud, and sometimes constricted above; more or less staggered; furrow shallow. Nodes rather long, considerably longer on the side to which the bud is attached; leaf-scar usually oblique; the portion above typically larger in diameter than that below; two or three rows of rudimentary roots; the depressed ring forming the portion below the leaf-scar medium depth and narrow. Buds typically expanded and projecting out from the stalk, but before starting adhering closely to the stalk and typically ovate to oval in outline; margin narrow and conforming to the shape of the bud, bearded at the point. Foliage abundant, medium green in color. Leaf medium width, length medium to short, growing erect, tapering rather abruptly to a fine point. Leaf-sheath flattened at the throat, reddish in color; auricles medium size but sometimes acute-pointed on one side of the stalk; ligula medium width, with the upper edge rounded to obtuse-pointed in the center. Vestiture of leaf-sheath a few short and fine setae on the back, rather closely appressed. Vestiture of throat of sheath medium long and coarse hairs on the auricles, the adjacent edges of the leaf, and sometimes a few behind the ligula. Most important distinguishing characters shape and size of the internodes and the buds.

B–6292.—Habit erect. Length long. Diameter small. Shape of stalk straight. Color light green to reddish-green, a glaucous ring on the node below the leaf-scar. Internodes almost round in cross-section, usually tumid on the side opposite the bud and slightly depressed on the bud side; furrow, when present, broad and shallow. Nodes medium size, longest on the bud side; the depressed ring forming the portion below the leaf-scar shallow. Buds usually having commenced to expand and standing out from the stalk, the shoot being acute-pointed and extending through the scales; when not having started to develop shoots the buds are typically broadly semi-elliptical in outline, with a margin of medium width. Foliage medium to abundant, medium green in color. Leaf narrow and long, tapering into a long point. Leaf-sheath slightly flattened at the throat; auricles large and obtuse-angular, except occasionally on one side of the stalk they are semi-acute pointed; ligula medium to long, with the upper edge rounded in outline. Vestiture of throat of sheath medium coarse hairs on the auricles and adjacent edges and surface of the leaf. Most important distinguishing characters the form of the buds and the long, slender stalk.

B–1753.—Habit erect to inclining. Length long. Diameter small. Shape of stalk straight. Color straw color to yellow, a glaucous

ring on the node below the leaf-scar. Internodes nearly round in cross-section, straight-sided or slightly depressed on the side on which the bud occurs, usually largest in diameter at the place of union with the node below; furrow shallow or none. Nodes medium to large; the portion above the leaf-scar long, typically large in circumference and appearing swollen, or expanding from the bottom upward to the lower limit of the internode; leaf-scar close to the stalk on the side opposite the bud but projecting out from beneath the bud; rudimentary roots very close together and in about four or five rows; the depressed ring forming the portion below the leaf-scar shallow. Buds close to the stalk, or slightly prominent; young buds typically flat against the stalk, ovate to acute, and with a narrow margin, uniform with the sides of the buds. Foliage rather scant, the leaves being shed far up on the stalk; light green in color. Leaf narrow, short, growing erect, tapering into a long point, sometimes breaking off at the throat and falling from the sheath. Leaf-sheath nearly round at the throat; auricles medium to large, sometimes long-pointed on one side of the stalk; ligula medium length, with the upper edge rounded in outline. Vestiture of leaf-sheath many soft setae. Vestiture of throat of sheath fine hairs on the auricles and adjacent edges and face of the base of the leaf. Most important distinguishing characters the shape and size of the nodes and buds, and the manner of growth of the leaves.

B–4596.—Habit erect to reclining. Length medium. Diameter medium to large, variable. Shape of stalk usually straight. Color yellowish-green to reddish green, usually more red just above the node, sometimes having spots of reddish-brown; glaucous, especially the lower portion of the nodes; having fine cracks in the epidermis. Internodes medium to long, more or less flattened, often larger above than below the node; typically straight-sided, plump; sometimes slightly tumid, sometimes subconical; often a typical shoulder just above the node on the side opposite the one having the bud; furrow medium depth. Nodes rather short; the depressed ring forming the portion below the leaf-scar distinct; rudimentary roots about two rows. Buds typically large and coarse but varying with the coarseness of the stalk, broad, obtuse to more or less acute pointed; the margin typically wide, with straight edges and large lobes; sometimes broadly ovate-acuminate in outline; occasionally starting and standing out slightly from the stalk but not producing sprouts. Foliage medium in amount, dry leaves readily shed. Leaf medium to broad, medium length, tapering into a point of medium length. Leaf-sheath flattened laterally at throat; auricles medium to small; ligula

medium length, with the upper edge rounded or slightly depressed in the center. Vestiture of leaf-sheath medium stiff, fine and short setae. Vestiture of throat of sheath medium fine hairs on the auricles, and adjacent edges and face of the base of the leaf; sometimes finely pubescent on the adjacent surface of the leaf. Most important distinguishing characters color and the form of the buds and the internodes.

B–376.—Habit erect to recumbent. Length long. Diameter medium. Shape of stalk more or less curved. Color varying from shades of greenish-red to straw color, and sometimes showing violet or purple tints; very glaucous. Internodes varying in length but averaging about medium; also varying much in shape, sometimes straight-sided and sometimes more or less tumid, mainly tumid on the side opposite to the one bearing the bud, typically plump, and slightly flattened laterally; furrow medium depth. Nodes medium size; the depressed ring constituting the portion below the leaf-scar distinct, deepest immediately below the bud; the upper portion usually about the same size as the internode, and often larger than the portion below; the leaf-scar adhering closely to the stalk on the side opposite the bud, but often projecting out prominently from beneath the bud; rudimentary roots three or four rows. Buds varying in relative length and width, usually plump, typically almost as broad as long and broadly ovate-acuminate to triangular in outline, obtuse to medium acute pointed; margin medium width, typically with distinct lobes; may or may not start to expand on the standing stalk. Foliage abundant, medium green in color, some of the dry leaves also adhere to the stalk. Leaf medium width, medium length, tapering into a long point. Leaf-sheath slightly flattened laterally at the throat; auricles medium size; ligula medium width, with the upper edge rounded in outline or sometimes slightly depressed in the center. Vestiture of leaf-sheath a few setae in a line in the back. Vestiture of throat of sheath medium coarse hairs on the auricles, adjacent edges of the base of the leaf, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters color and the form of the internodes, and the buds.

Seeley Seedling.—Habit erect to inclining. Length long. Diameter medium to small. Shape of stalk slightly curved. Color greenish-red, but varying in redness with the amount of sun-exposure; the depressed ring of the node below the leaf-scar glaucous. Internodes medium to long, almost round in cross-section; typically straight or slightly depressed from the bud upwards, but more or less tumid on the opposite side; furrow just perceptible. Nodes medium size, typically

smaller below the leaf-scar than above it, longer on the side of the bud; about three rows of rudimentary roots. Buds usually having started to expand, projecting through the outer scales and standing out from the stalk; before starting typically semi-elliptical to broadly ovate in outline and adhering closely to the stalk; fairly plump; margin medium in width; lobes inconspicuous. Foliage rather less than medium, medium to dark in color. Leaf narrow, medium length, tapering rather gradually into a point. Leaf-sheath nearly round at the throat, usually reddish in color; auricles medium size; ligula medium to short, with the upper edge rounded in outline. Vestiture of leaf-sheath medium stiff setae. Vestiture of throat of sheath medium coarse hairs on the auricles, and a few extending up onto the adjacent edges and surface of the leaf. Most important distinguishing characters color and the shape of the internodes and the buds.

B–3747.—Habit erect to inclining. Length long. Diameter medium. Shape of the stalk straight. Color yellowish-green to reddish-green; more or less glaucous, especially the depressed ring forming the lower portion of the node. Internodes flattened; typically slightly larger in the upper portion, and with a tendency to be tumid, especially the shorter internodes and on the side opposite to the bud; the side on which the bud occurs is almost straight immediately above the bud, but often a little tumid just below the node; sometimes staggered; furrow rather broad but shallow. Nodes medium size, the portion above the leaf-scar longer on the side on which the bud is attacked than on the opposite; rudimentary roots quite abundant and distinct, in two or three rows; the depressed ring forming the lower portion of the node narrow and shallow; the leaf-scar more or less oblique and projecting from beneath the bud, ciliated with more or less deciduous hairs. Buds large or small, depending on the size of the stalk; often short in comparison with their breadth, triangular to ovate in outline, occasionally long and appearing shrunken; typically obtuse or blunt pointed, and with a narrow margin and having edges conforming to the shape of the bud. Foliage medium in amount, medium green in color. Leaf medium to broad, long, tapering into a long, acute point. Leaf-sheath distinctly flattened laterally at the throat; auricles small; ligula narrow, upper edge either rounded, slightly pointed, or slight depressed in the center. Vestiture of leaf-sheath many rather long and soft setae. Vestiture of throat of sheath hairs on auricles, adjacent edges of leaf, and sometimes a few on the adjacent areas of the face of the leaf. Most important distinguishing characters form of the buds and the internodes, and the ciliated leaf-scar.

B–3750.—Habit erect to inclining. Length medium. Diameter medium. Shape of stalk straight to slightly curved. Color greenish-yellow, sometimes reddened on the upper internodes; glaucous on the lower portion of the node. Internodes medium to long, slightly flattened; typically almost straight-sided, but slightly tumid on the side opposite to the one which bears the bud and a little larger on the upper portion; slightly staggered; furrow shallow or none. Nodes medium to small, the portion above the leaf-scar medium to short and longest on the side on which the bud is attached; two or three rows of rudimentary roots; the leaf-scar and the portion below it usually somewhat oblique; the former projecting prominently from beneath the bud. Buds medium size; typically broadly triangular in outline, having a wide margin with nearly straight edges; young buds more or less broadly ovate; scales of fine texture. The characteristic buds of this variety are those occurring more or less frequently on the upper part of the stalk, the margins having slightly increased in length and width. Foliage medium abundant, medium green in color. Leaf medium width, long, growing semi-erect, tapering into a long point. Leaf-sheath flattened at the throat; auricles small, sometimes acute-pointed on one side of the stalk; ligula short, with the upper edge rounded or slightly depressed in the center. Vestiture of leaf-sheath many setae which are long, rather soft, and not closely appressed. Vestiture of throat of sheath medium coarse hairs on the edges of the base of the leaf and the auricles, and sometimes fine hairs on the surface of the base of the leaf. Most important distinguishing characters the form of the internodes and of the buds.

B–3390.—Habit erect. Length medium to long. Diameter medium. Shape of stalk usually straight. Color reddish-green to green; more or less glaucous. Internodes nearly round in cross-section; sides typically nearly straight, but the longer internodes larger above the node than below it, and sometimes slightly constricted; often curved in above the bud and correspondingly tumid on the opposite side; furrow shallow and inconspicuous. Nodes medium size; rather larger above the leaf-scar than below it and largest on the bud side; below it a depressed ring of medium dimensions; rudimentary roots large and prominent, in two to four rows. Buds rather small, usually adhering closely to the stalk; margin typically subovate to acute in outline of medium width and conforming to the shape of the bud. Foliage medium abundant, medium green in color. Leaf medium to narrow, sub-erect, tapering into a long point. Leaf-sheath somewhat flattened at the throat, slightly glaucous; auricles medium to large; ligula medium in width, with the upper edge

slightly depressed in the center. Vestiture of leaf-sheath none. Vestiture of throat of sheath medium soft hairs on and adjacent to the auricles; also sometimes slightly pubescent on the face of the base of the leaf. Most important distinguishing characters the form of the internodes and the buds.

B–7169.—Habit erect. Length medium. Diameter medium. Shape of the stalk usually straight. Color yellowish-green to reddish-green, having a somewhat glossy surface and sometimes with a few fine cracks in the epidermis; the lower portion of the node sometimes glaucous. Internodes medium length, nearly round in cross-section; typically almost straight-sided but a little tumid on the side opposite the bud; the lower portion often slightly the largest and becoming smaller until the node is reached; furrow none or very shallow. Nodes medium size; almost uniform in length around the stalk, but the portion above the leaf-scar sometimes longer, and that below a little shorter on the bud side, the leaf-scar then being set at an angle; three or four rows of rudimentary roots, which show as white points. Buds regular in shape; typically ovate to acute in outline and acute-pointed; usually flat against the stalk but occasionally slightly prominent; margin narrow, with the edges straight or conforming to the shape of the bud; lobes small; scales of fine texture. Foliage abundant, medium green in color. Leaf medium to narrow, medium length, sub-erect, tapering into a medium long point. Leaf-sheath flattened laterally at the throat; auricles medium to small; ligula medium length, with the upper edge rounded to sub-elliptical. Vestiture of leaf-sheath a band of setae on the back, rather long and medium stiff. Vestiture of throat of sheath medium fine hairs on the auricles, adjacent edges and face of the leaf, and sometimes a few behind the ligula. Most important distinguishing characters color and glossy appearance, and the form of the internodes and the buds.

B–3405.—Habit erect to inclining. Length medium to long. Diameter medium. Shape of stalk nearly straight. Color reddish-green, being reddest in the upper internodes and where exposed to the sun; often glaucous on lower portion of the node. Internodes medium length, slightly flattened, typically slightly tumid on the side opposite the one which bears the bud, and sometimes a little sub-conical; often slightly staggered; furrow shallow but usually broad. Nodes medium size; leaf-scar often oblique and usually projecting prominently from beneath the bud; the portion above the leaf-scar rather long; the depressed ring forming the portion below medium width and shallow, excepting immediately below the bud where it

is deeper; two or three rows of rudimentary roots. Buds typically having started to expand on the standing cane and projecting from the stalk; before starting semi-elliptical to broadly ovate in outline; margin narrow in the young buds but appearing wide in the older ones, typically semi-elliptical pointed; lobes inconspicuous; sometimes slightly barbate at the point and barbellate on the sides. Foliage medium to scant, medium green in color, dry leaves well shed. Leaf medium to narrow, long, tapering into a long and fine point. Leaf-sheath almost round at throat, slightly glaucous; auricles medium to large; ligula medium width, with the upper edge either rounded in outline or slightly depressed in the center. Vestiture of leaf-sheath many setae, which are rather long and medium stiff. Vestiture of throat of sheath long and medium course hairs on the auricles and adjacent edges of the leaf, and sometimes a few on the adjacent areas of the face of the leaf. Most important distinguishing characters the form of the buds and the internodes.

D–117.—Habit erect. Length long. Diameter medium. Shape of the stalk straight. Color light green to yellowish-green. Internodes medium to long, slightly flattened; typically straight on the side opposite to the one on which the bud occurs, but on the bud side largest at the base and extending up nearly straight from that point; sometimes slightly constricted above the enlargement at the base; furrow, when present, shallow but rather broad. Nodes large, typically largest on the bud side above the leaf-scar; often a slightly prominent ring at the line of union with the internode above; leaf-scar projecting prominently from beneath the bud; rudimentary roots many and close together, in three or four rows. Buds typically broadly-ovate to triangular in shape and medium acute-pointed; margin medium to narrow, and uniform in width with the sides of the bud; lobes inconspicuous or none; sometimes bearded at the point and barbellate on the sides. These buds sometimes start to expand on the standing stalk, but they do not become prominent; the sprout from the bud is plump and medium obtuse pointed. Foliage medium in amount, medium green in color, some of the dry leaves are retained. Leaf medium in width, medium length, tapering into a medium long point. Leaf-sheath slightly flattened laterally at the throat; auricles medium size but sometimes long-pointed on one side of the stalk; ligula short, with the upper edge either rounded or slightly depressed in the center. Vestiture of leaf-sheath a few medium soft setae. Vestiture of throat sheath long hairs on the auricles, adjacent edges of the leaf, and sometimes finer hairs on the adjacent surface of the base of the leaf; also more or less pubescent

on the face of the base of the leaf. Most important distinguishing characters the shape of the internodes, nodes and buds.

D–109.—Habit inclining to recumbent. Length medium to long. Diameter medium. Shape of the stalk curved. Color dark purple to greenish-red; abundantly glaucous. Internodes medium to long, slightly flattened; typically tumid, especially so in the lower part, making them sub-conical; furrow shallow or imperceptible. Nodes medium to small, regular in shape; usually as dark or darker than the internodes, when on the lower part of the stalk, but lighter and greener above; two or three rows of rudimentary roots. Buds nearly all having started to expand on the standing stalk; scales usually lighter in color than the shoot; the young buds typically plump, fairly uniform and ovate to oval in outline; margin narrow, and in the young buds, semi-elliptical at the point; having inconspicuous lobes on the sides; slightly bearded at the tip. Foliage abundant, dark in color. Leaf medium to broad, medium length, gradually tapering into a fine point. Leaf-sheath compressed laterally at the throat, reddish in color, very glaucous; auricles medium size, sometimes long-pointed on one side of the stalk; ligula short, with the upper edge more or less pointed in the center. Vestiture of leaf-sheath a few setae in a narrow line on the back. Vestiture of throat of sheath soft hairs on the auricles and adjacent edges of the leaf, and sometimes pubescent on the surface of the base of the leaf blade. Most important distinguishing characters color and the form of the internodes and the buds.

D–625.—Habit erect. Length medium to long. Diameter large. Shape of stalk usually straight. Color light yellowish-green to yellow; reddish brown rings at the upper limit of the nodes, especially on the upper portion of the stalk; the portion of the node below the leaf-scar glaucous. Internodes medium to long, nearly round in cross-section; the sides typically nearly straight but sometimes slightly constricted and sometimes a little tumid on the side opposite the bud; sometimes a little staggered; furrow broad but shallow. Nodes medium to large; the portion above the leaf-scar long and usually as large, or larger, in diameter than the internode above; rudimentary roots rather far apart, in two or three rows; the depressed ring forming the portion below very shallow. Buds large and quite uniform in shape; typically plump and broadly triangular to ovate in outline; margin medium to narrow and conforming to the shape of the bud; often bearded at the apex and barbellate on the sides of the margin. Foliage medium to scant, color medium green. Leaf medium width, medium length, sub-erect, tapering into

a fine point medium abruptly. Leaf-sheath nearly round at the throat; auricles small; ligula medium length, with the upper edge usually rounded, but sometimes slightly pointed, and sometimes slightly depressed in the center. Vestiture of leaf-sheath many soft setae. Vestiture of throat of sheath medium fine hairs on the auricles and adjacent edges of the leaf, and sometimes behind the ligula; sometimes finely pubescent on the face of the base of the leaf. Most important distinguishing characters form and size of the internodes and buds, and the brown ring on the node.

EXPLANATION OF PLATES.

Plate X.

Fig. 1.—A bud of Yellow Caledonia cane, showing a narrow, uniform margin, without lobes, and a barbate apex. × about 3½.

Fig. 2.—A bud of B 208, showing a margin with large lobes and a barbate apex. × about 3.

Fig. 3.—A bud of the same variety, expanded, showing the globoid point. × about 3.

Fig. 4.—A portion of the leaf-sheath of Cavengerie cane, showing setae. × about 3½.

Fig. 5.—The ciliated leaf-scar, occurring on B 3747, B 1355 and B 1356. × about 3½.

Plate XI.

Fig. 1.—Otaheite. Distinguished by its somewhat tumid internodes and its sub-eliptical to ovate buds. × about ⅔.

Fig. 2.—Rayada. Distinguished by its stripes and the broadly ovate to ovate-acuminate buds. × about ¾.

Plate XII.

Fig. 1.—Crystallina. Distinguished by its glaucousness, its typical plump internodes and its broadly ovate-acuminate to triangular buds. × about ¾.

Fig. 2.—Yellow Caledonia. Distinguished by its almost cylindrical internodes and the fine cracks in the epidermis of the internodes. × about ⅗.

Plate XIII.

Fig. 1.—B 347. Distinguished by its long ovate to oval buds, and the light-colored blotches on the internodes. × about ½.

Fig. 2.—B 3412. Distinguished by the medium thin stalks and the prominant expanded buds. × about ¾.

Plate XIV.

Fig. 1.—B 208. Distinguished by its plump internodes, the shoulder above the node, and the expanded, globoid buds. × about ⅝.

Fig. 2.—B 6450. Distinguished by the shape of the internodes and the ovate to triangular buds. × about ⅔.

Plate XV.

Fig. 1.—B 3859. Distinguished by the more or less staggered and tumid internodes and the plump, expanded buds. × about ⅔.

Fig. 2.—B 4596. Distinguished by its straight-sided, almost cylindrical internodes, and the wide margin and large lobes of the buds. × about ⅝.

Plate XVI.

Fig 1.—B 3747. Distinguished by the shape of the internodes and its ciliated leaf-scar. × about ⅗.

Fig. 2.—B 7169. Distinguished by its glossy surface, the almost straight-sided internodes and the regular, ovate to acute buds. × about ¾.

Plate XVII.

Fig. 1.—B 3405. Distinguished by its slightly tumid to sub-conical internodes and its broadly semi-eliptical to broadly ovate, usually expanded, buds. × about ⅔.

Fig. 2.—D 117. Distinguished by the large nodes, the shape of the internodes and the broadly ovate to triangular buds. × about ⅔.

Plate XVIII.

Fig. 1.—D 109. Distinguished by the tumid or sub-conical internodes and the usually expanded buds. × about ⅗.

Fig. 2.—D 625. Distinguished by the thick, erect-growing stalks, its almost cylindrical internodes, the brown ring on the nodes, and the regular, plump broadly ovate to triangular buds. × about ⅔.

PLATE X.

CHARACTERS OF VARIETIES OF SUGAR CANE.

Fig. 1.

Fig. 2.

Fig. 3.

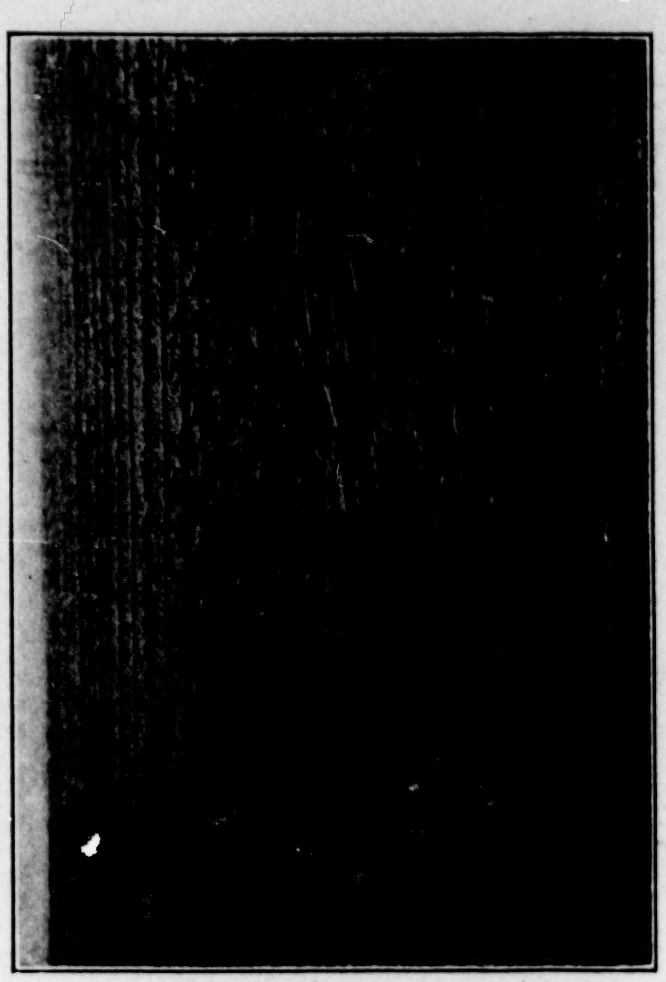

Fig. 4.

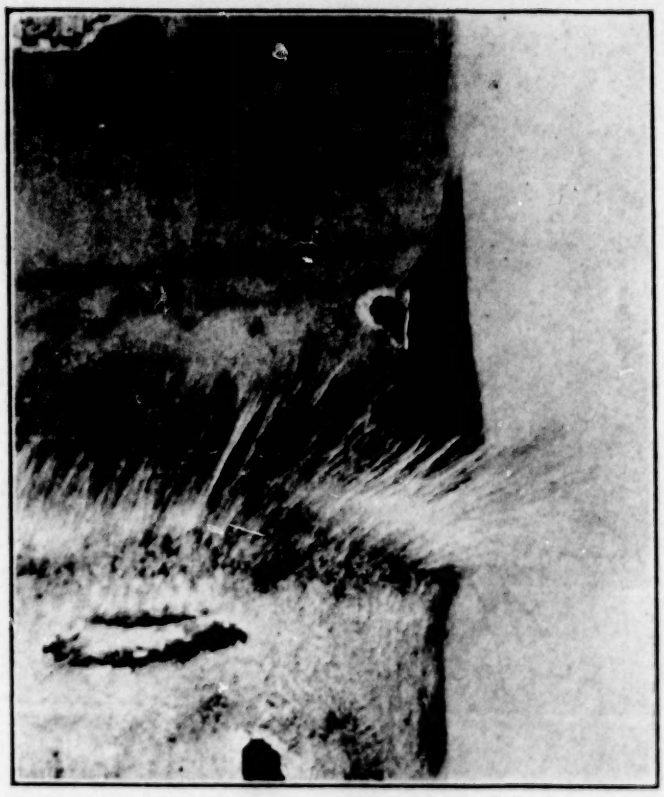

Fig. 5.

PLATE XI.

SUGAR-CANE VARIETIES OF PORTO RICO.

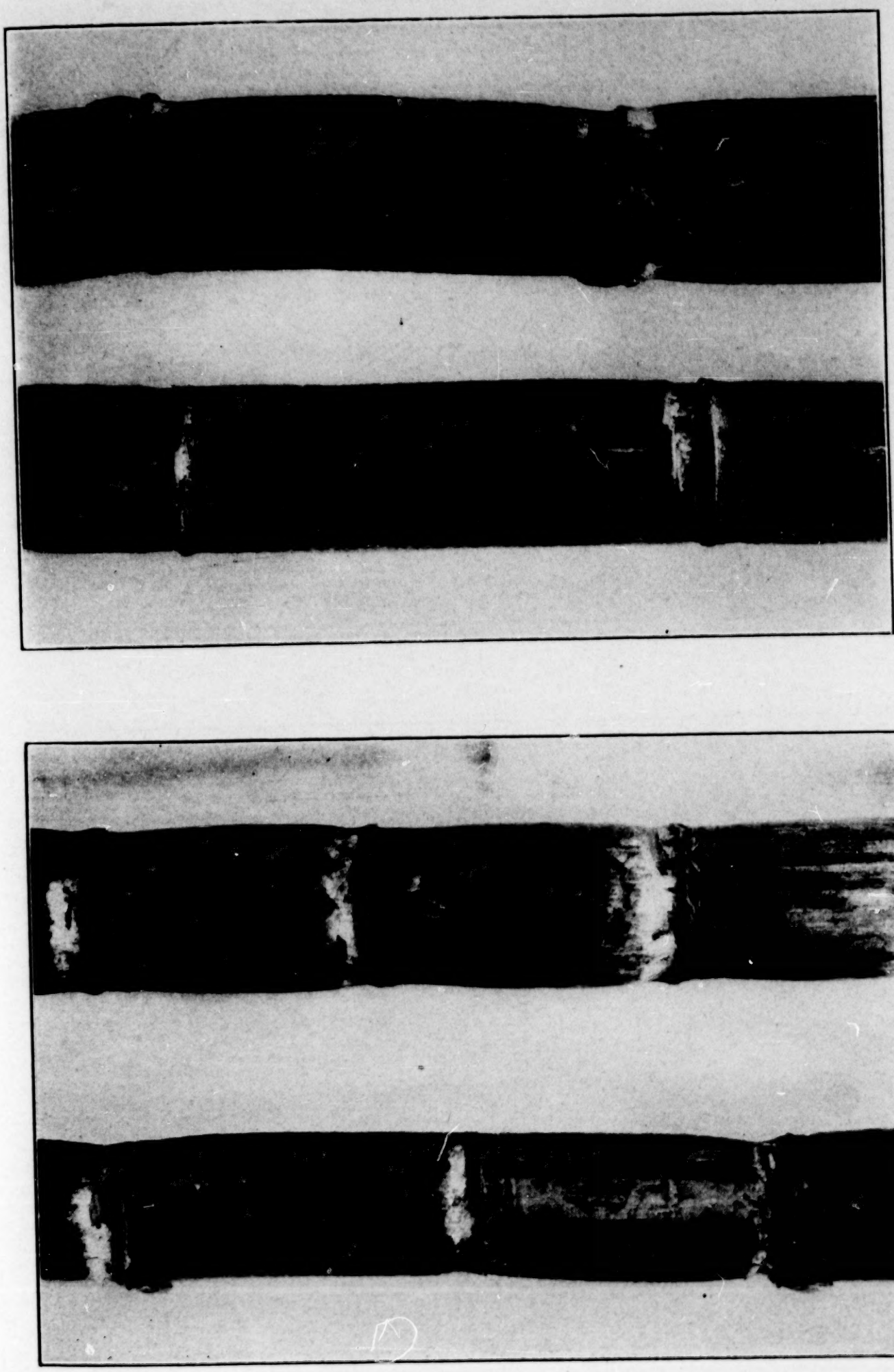

Fig. 2.

Fig. 1.

PLATE XII.

SUGAR-CANE VARIETIES OF PORTO RICO.

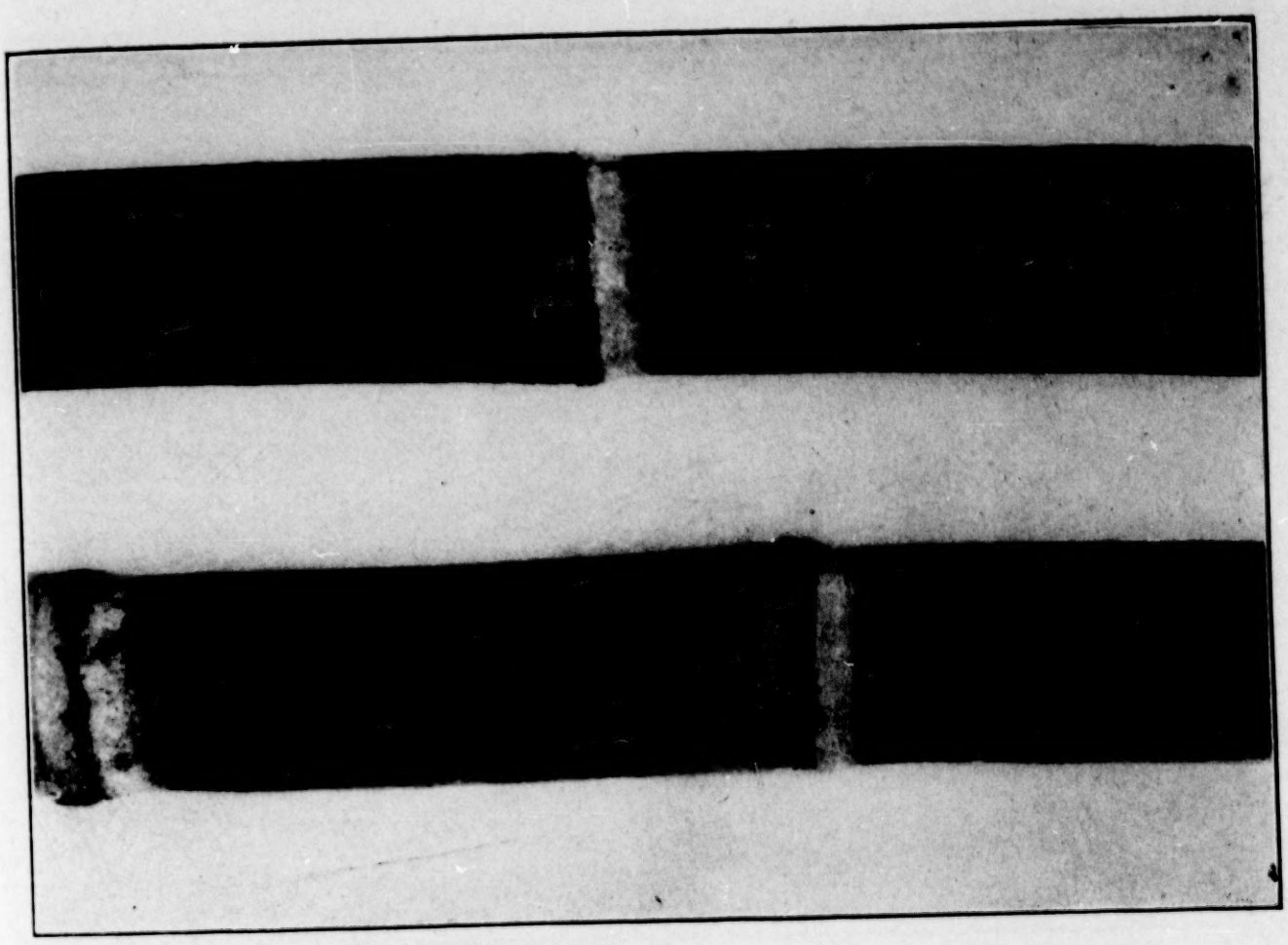

Fig. 2.

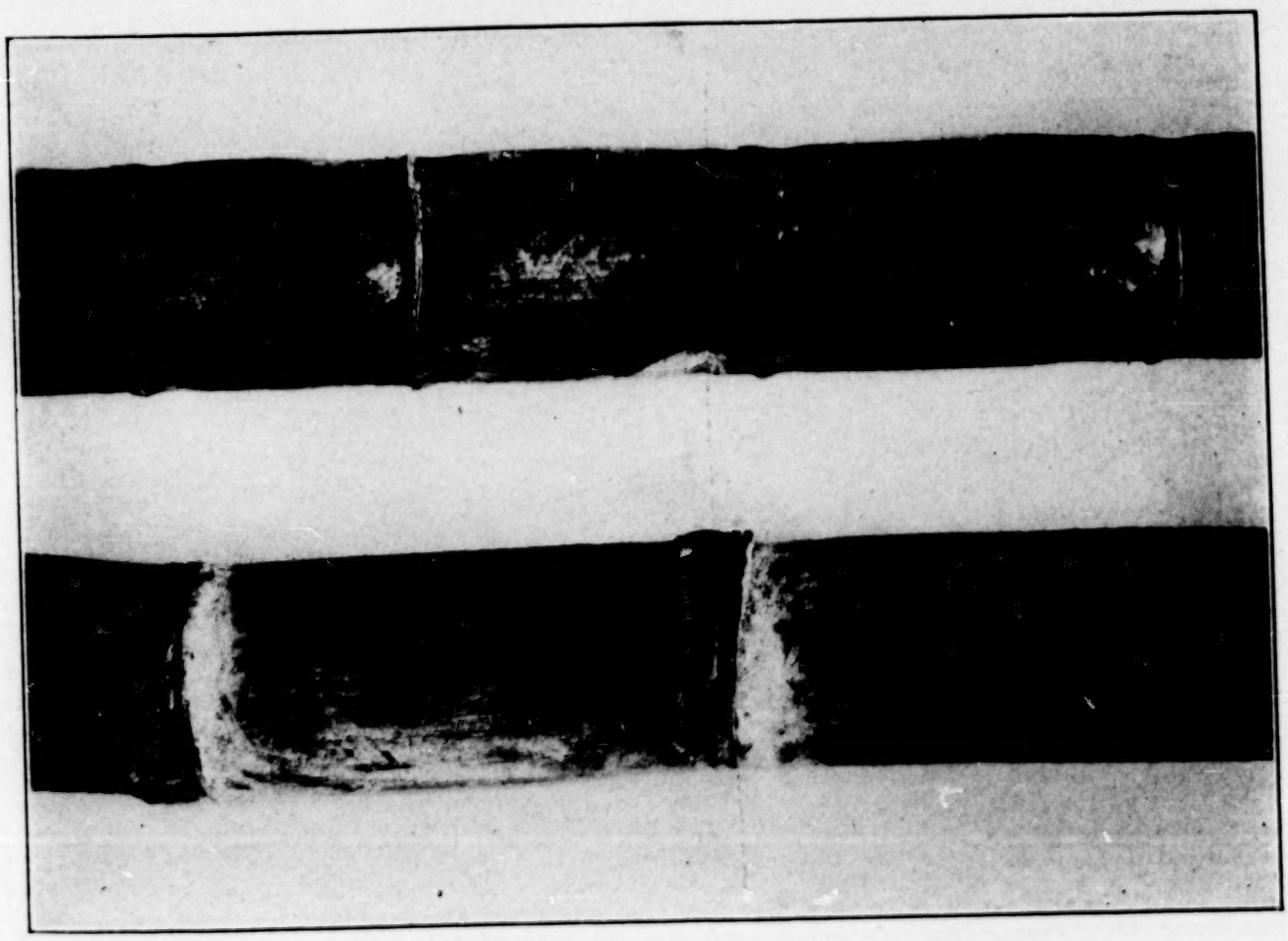

Fig. 1.

PLATE XIII.

SUGAR-CANE VARIETIES OF PORTO RICO.

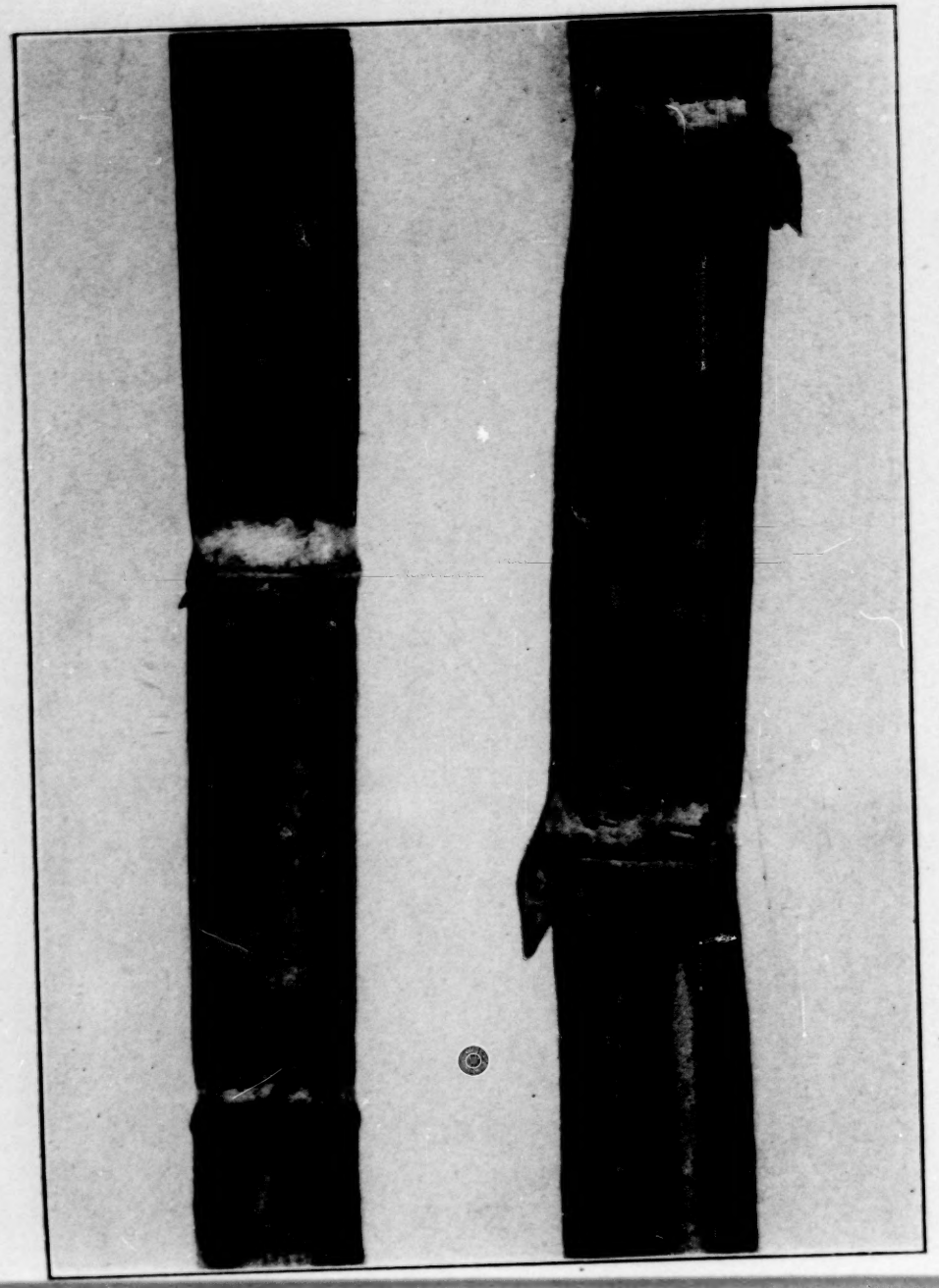

Fig. 2.

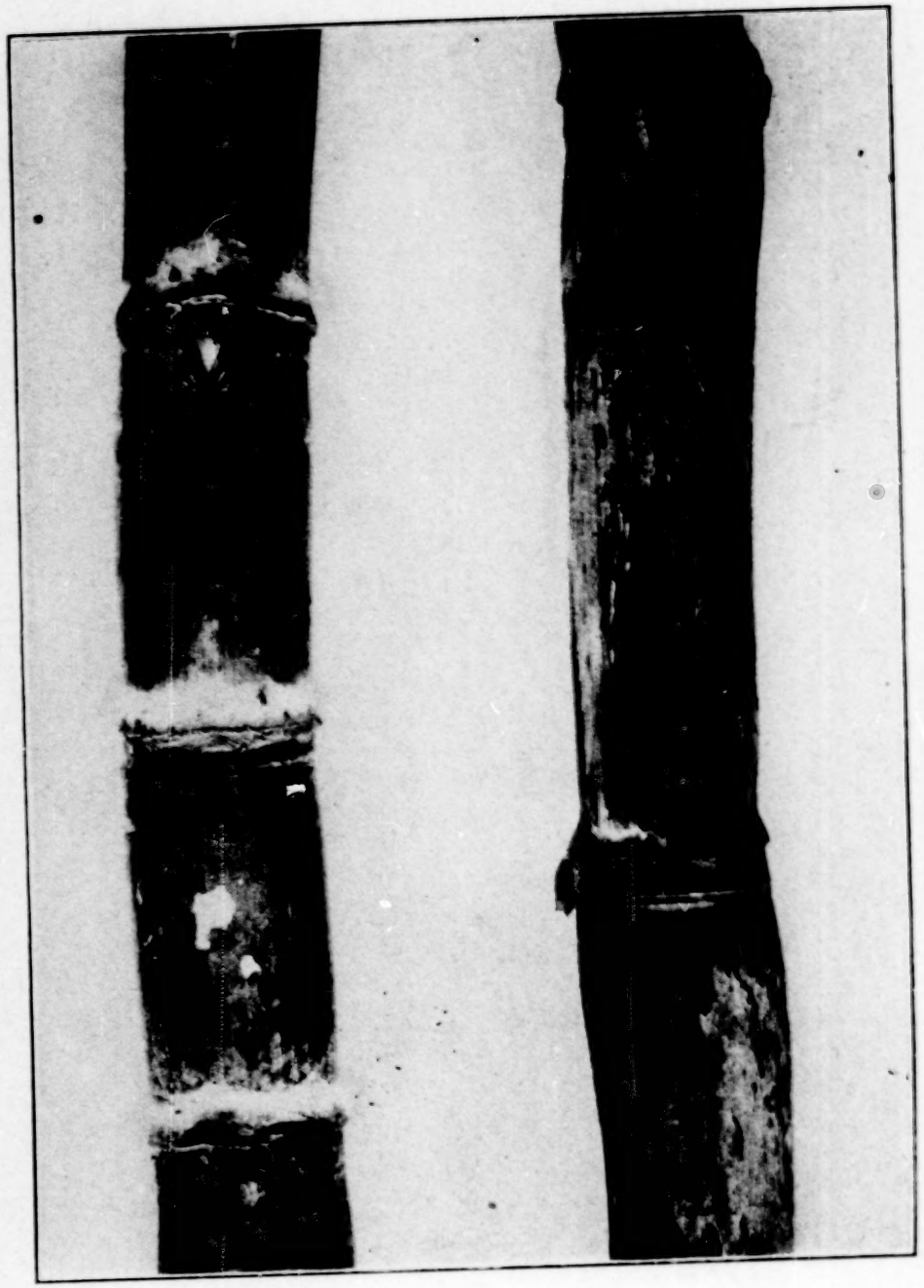

Fig. 1.

PLATE XIV.

SUGAR-CANE VARIETIES OF PORTO RICO.

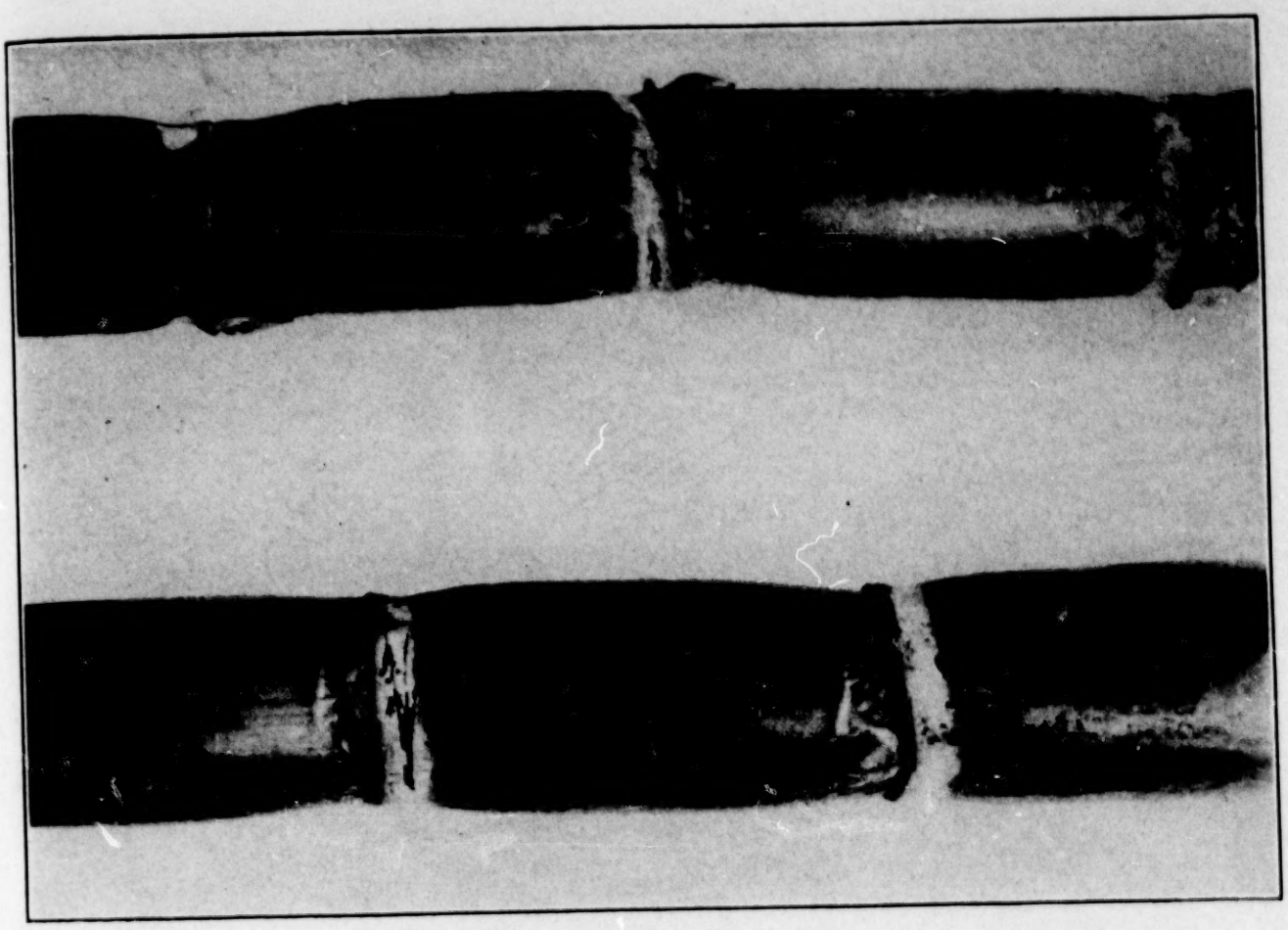

Fig. 2.

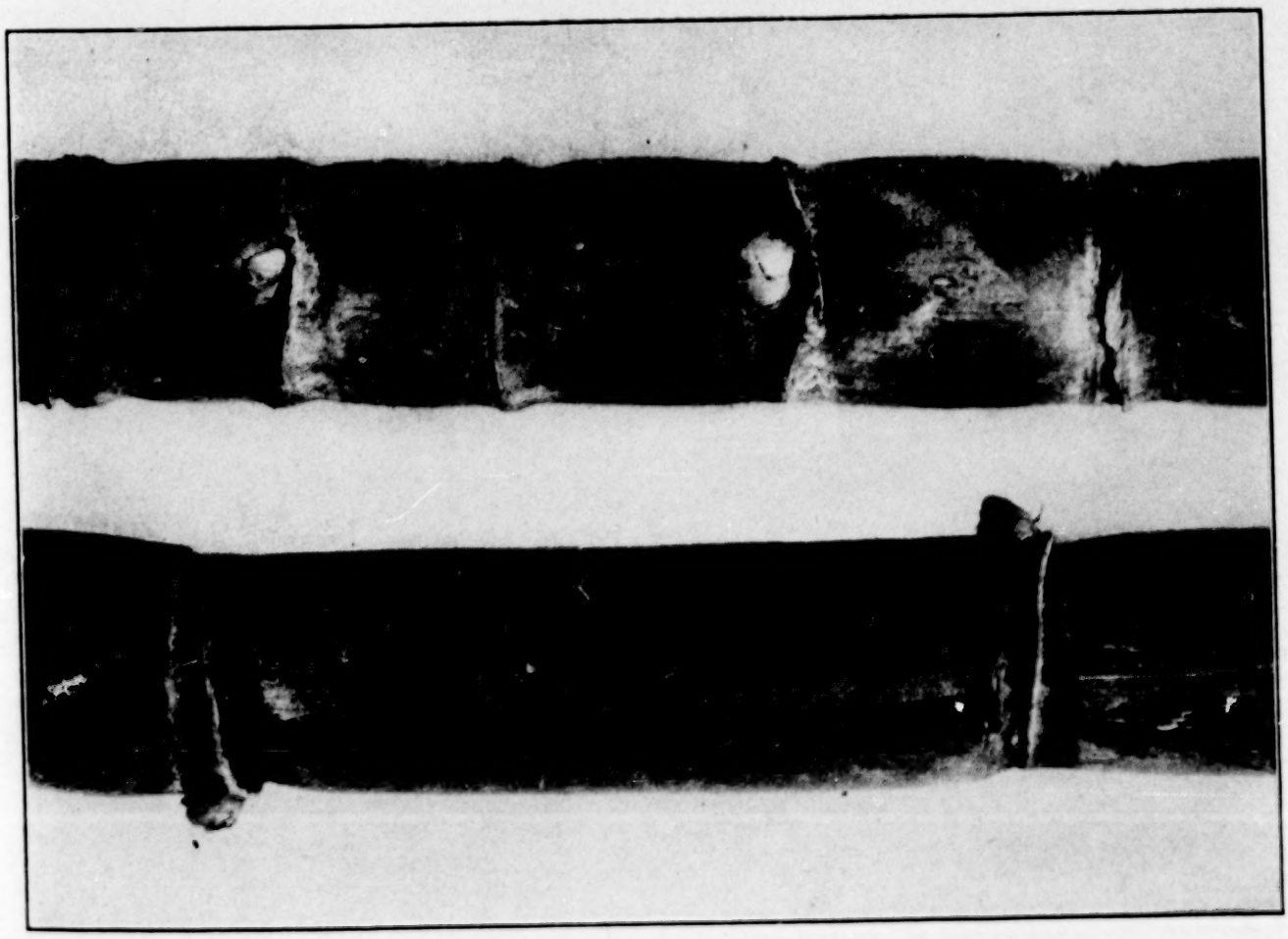

Fig. 1.

PLATE XV.

SUGAR-CANE VARIETIES OF PORTO RICO.

Fig. 1.

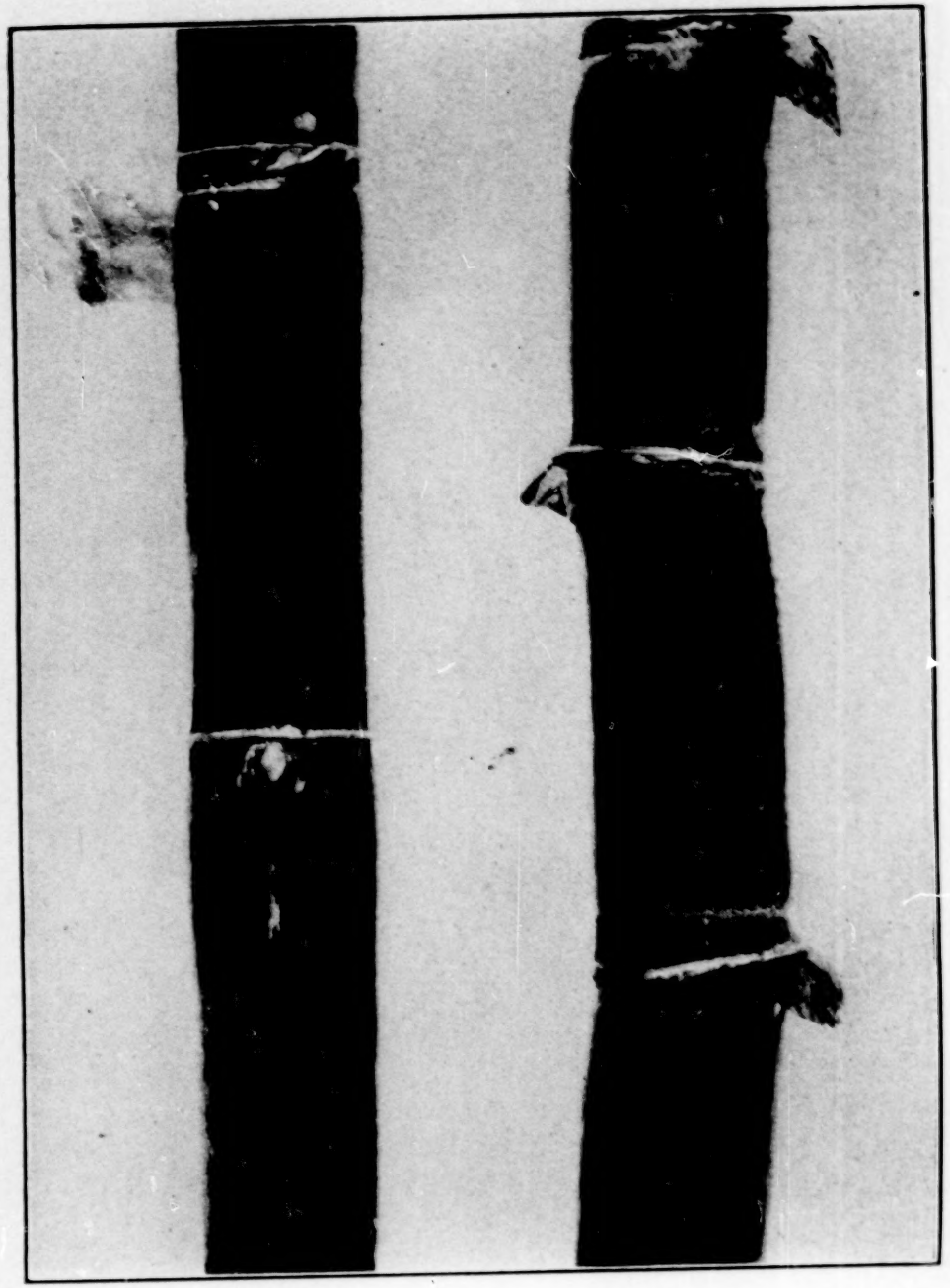

Fig. 2.

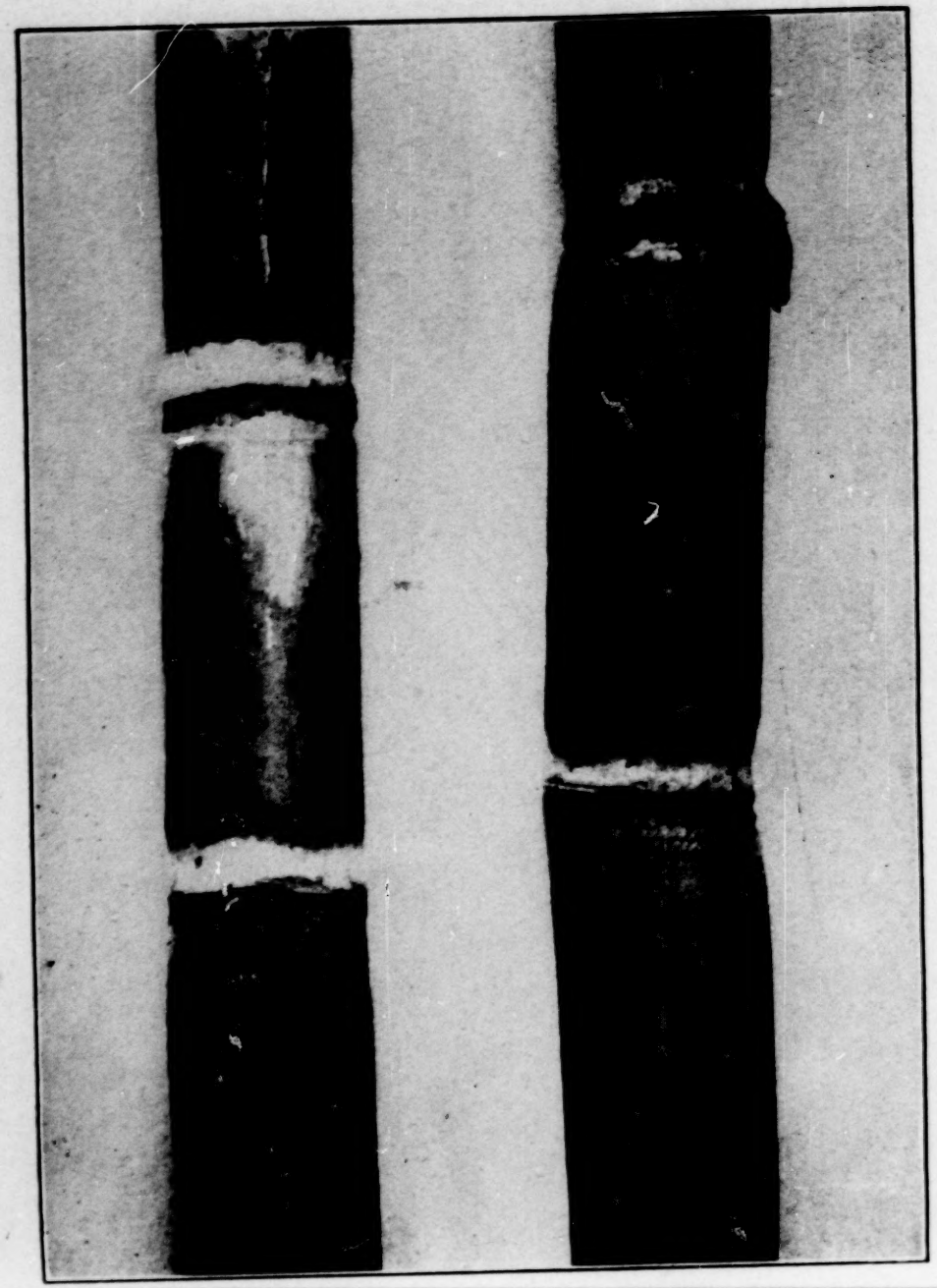

PLATE XVI.

SUGAR-CANE VARIETIES OF PORTO RICO.

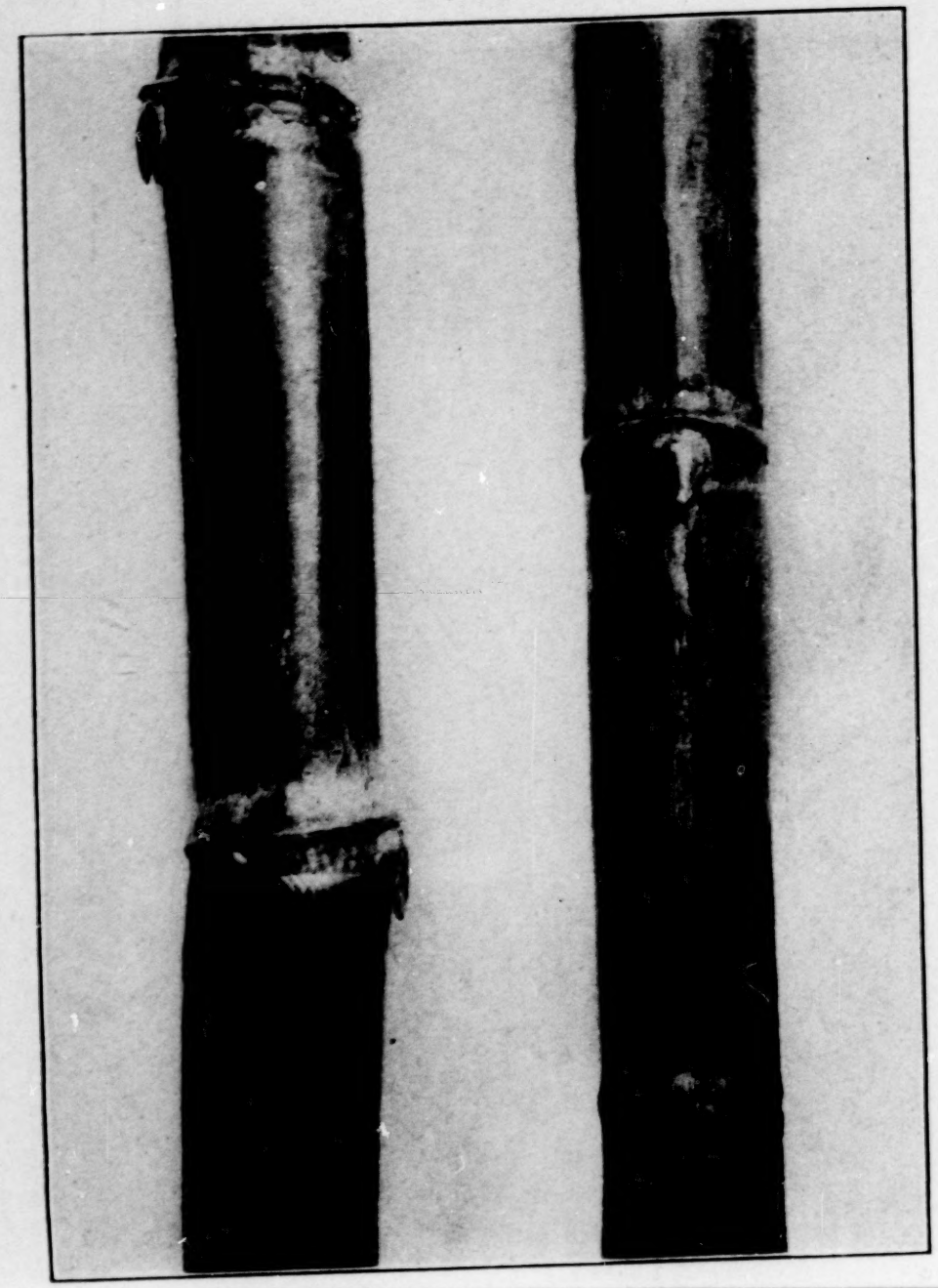

Fig. 2.

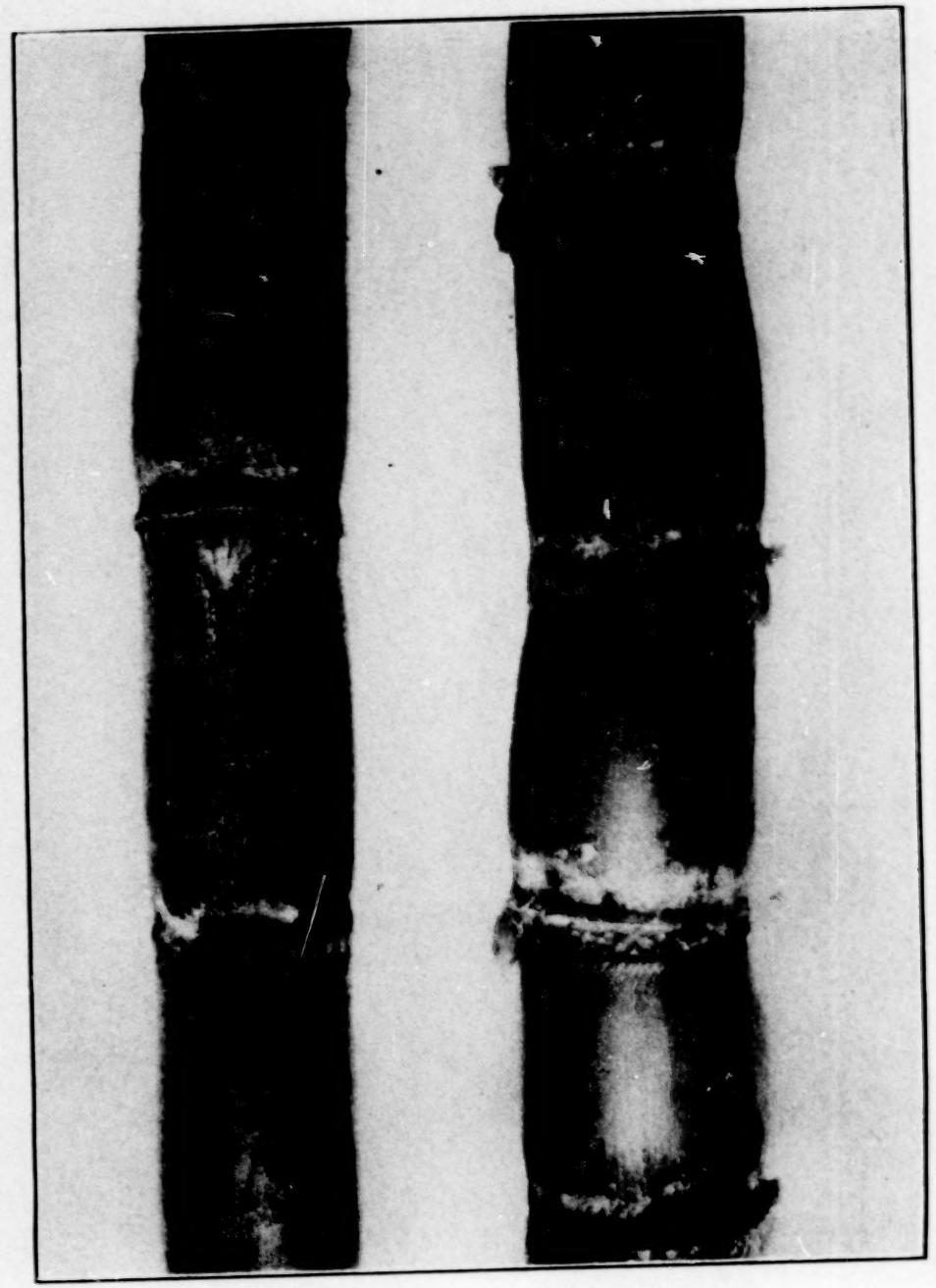

Fig. 1.

PLATE XVII.

SUGAR-CANE VARIETIES OF PORTO RICO.

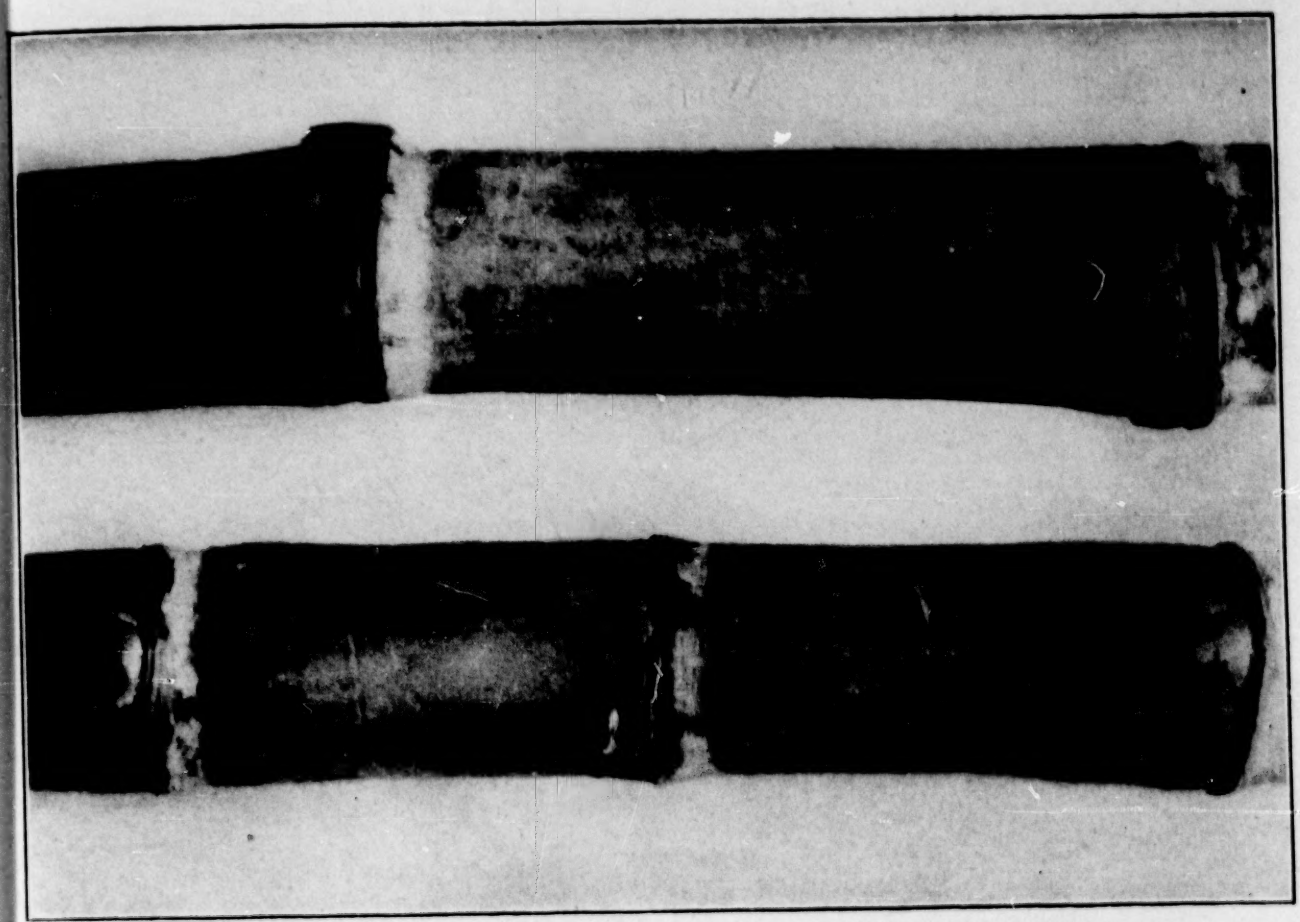

Fig. 2.

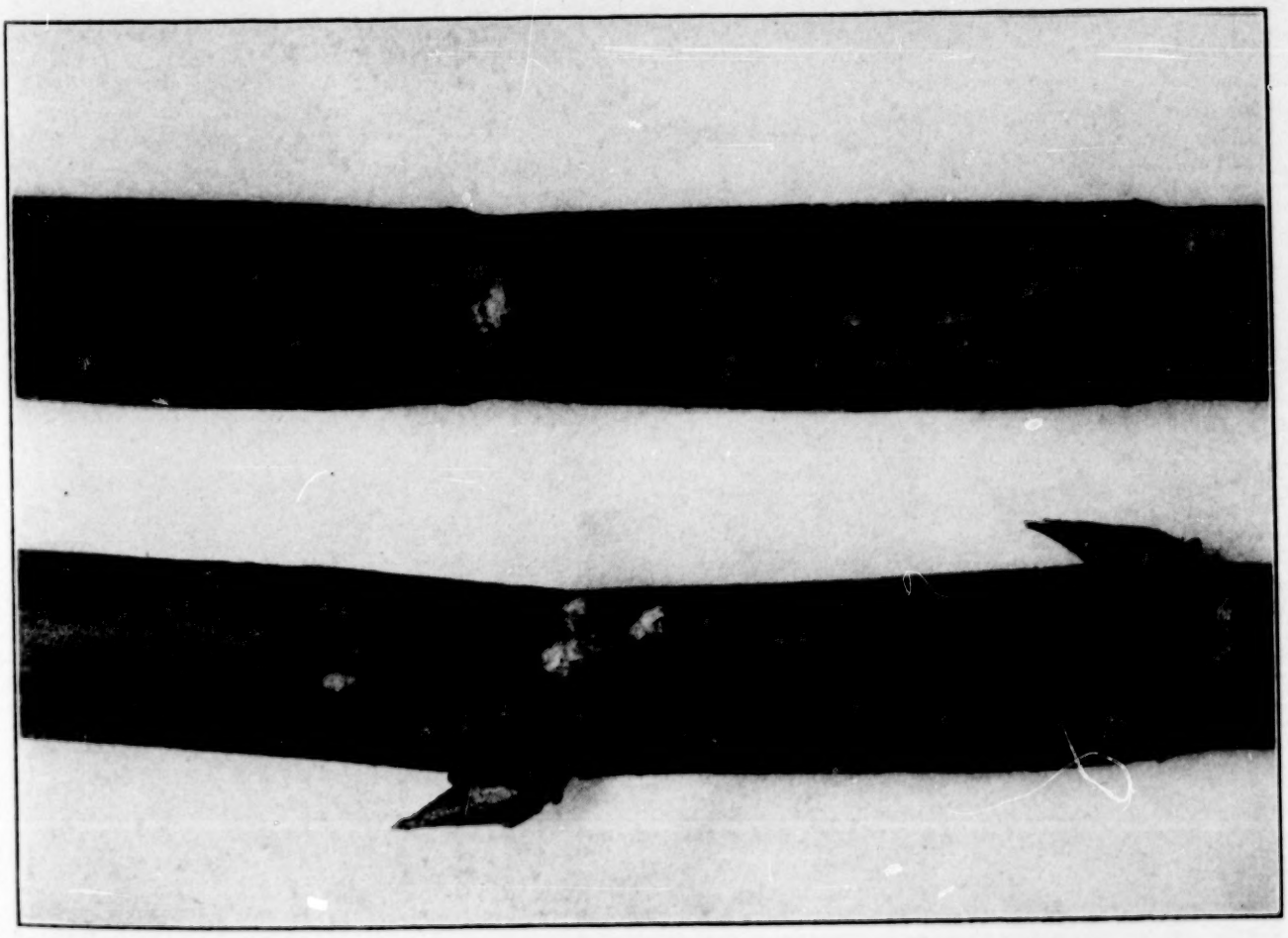

Fig. 1.

PLATE XVIII.

SUGAR-CANE VARIETIES OF PORTO RICO.

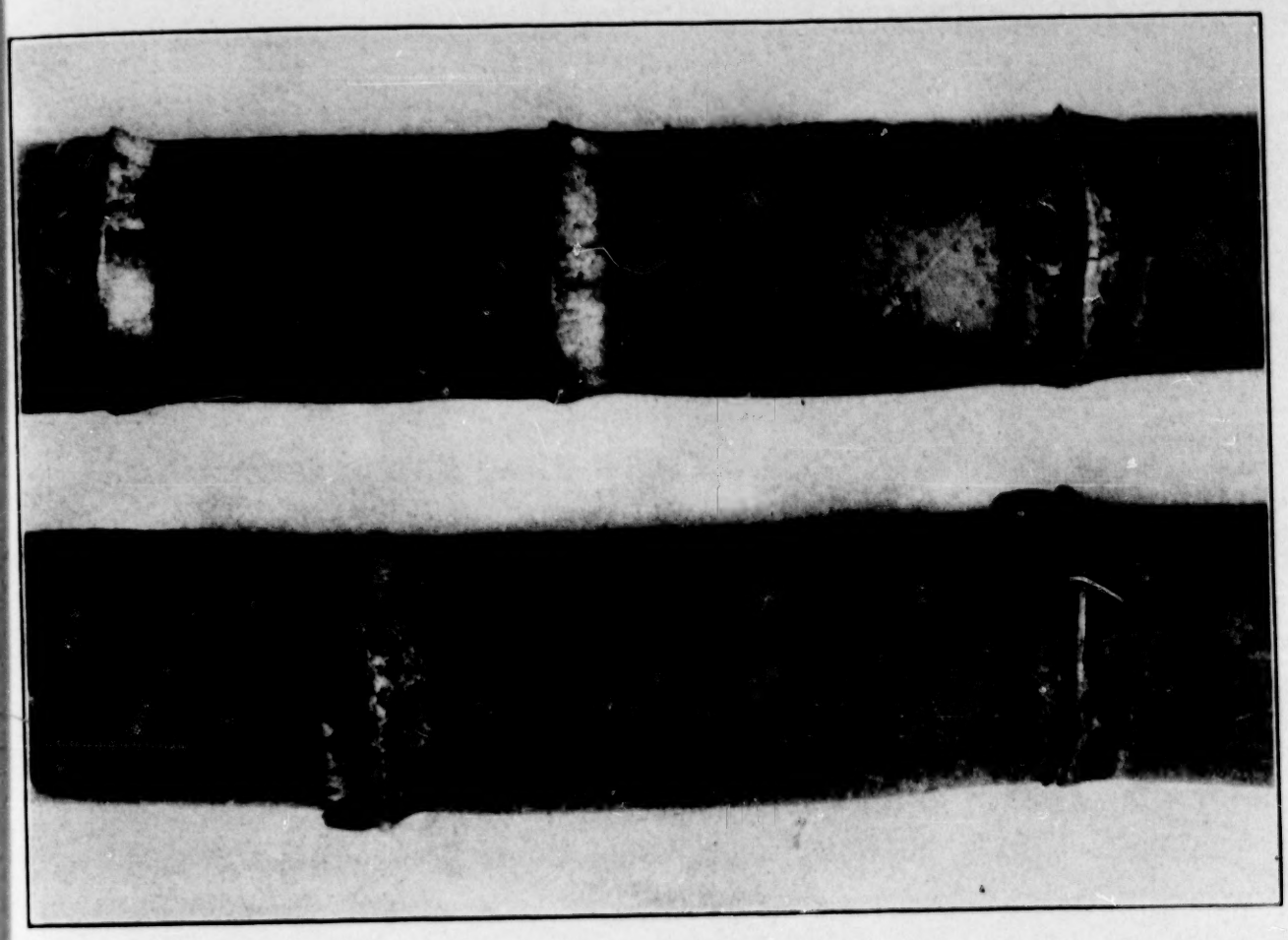

Fig. 2.

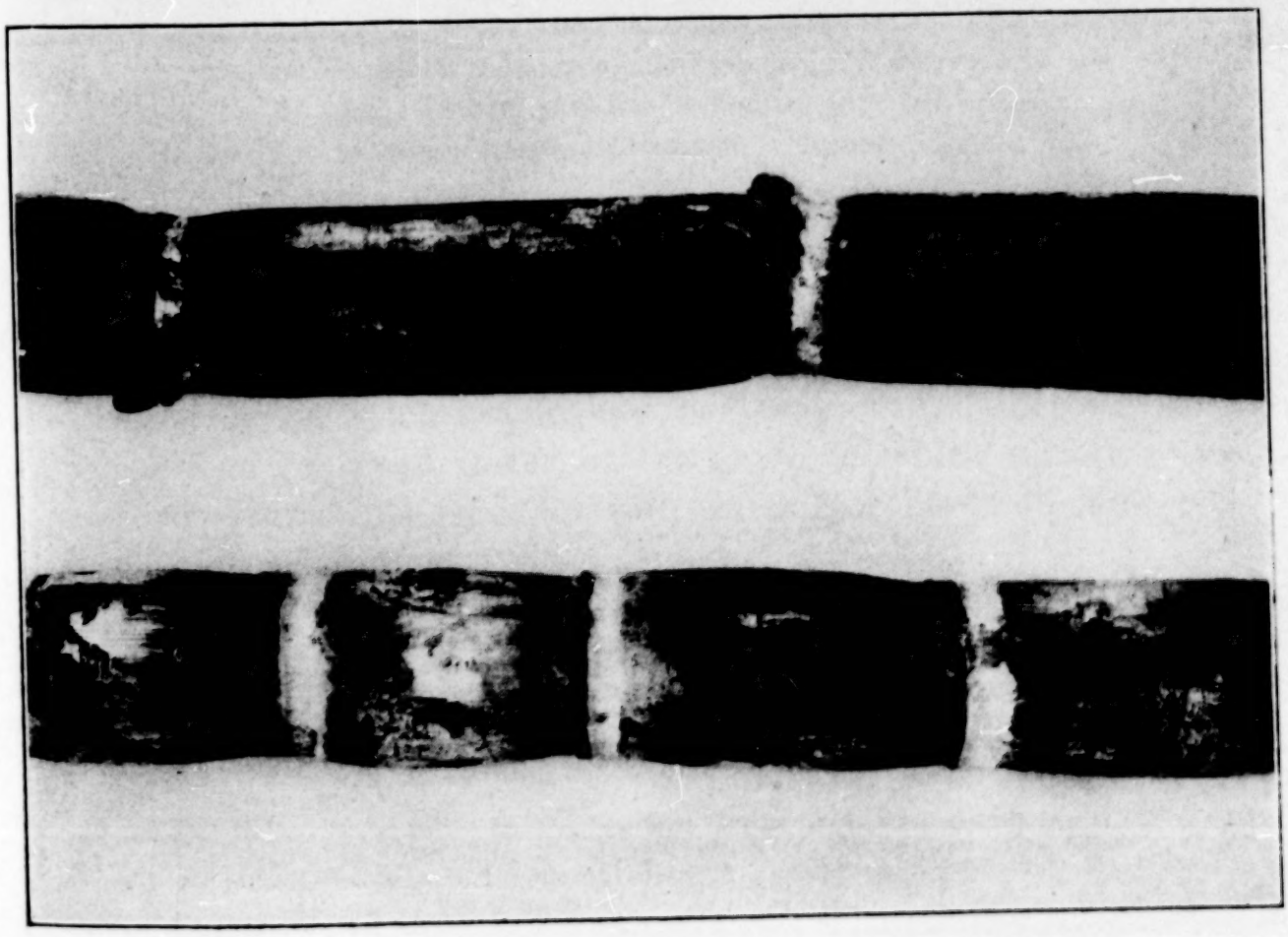

Fig. 1.

THE WHITE-GRUBS INJURING THE SUGAR CANE IN PORTO RICO.

1. LIFE-HISTORIES OF MAY-BEETLES—Continued.

By EUGENE G. SMYTH, Acting Entomologist, Insular Experiment Station.

THE SUGAR CANE WHITE-GRUB—Continued.

INFECTION BY THE METARRHIZIUM FUNGUS.

Infection of *Phyllophaga vandinei* n. sp.* in the experimental jars and boxes by the green muscardine fungus, *Metarrhizium anisopliae* (also known as *Entomopthora anisopliae* and *Isaria destructor*), has been noted of every stage except the pupa. The number of specimens that developed the disease, as compared to the total number kept in confinement under close observation, may be summed up in the following table:

Of 853 adults kept in confinement, 81 became infected, or 9.5 per cent.
Of 1,502 eggs kept in confinement, 10 became infected, or .66 per cent.
Of 852 grubs, 1st instar in confinement, 3 became infected, or .36 per cent.
Of 209 grubs, 2d instar in confinement, 3 became infected, or 1.43 per cent.
Of 117 grubs, 3d instar in confinement, 16 became infected, or 13.67 per cent.
Of 48 pupae kept in confinement, none became infected.

The majority of diseased specimens were adults, which is possibly accounted for by the fact that they, moving about freely in the jars, are more apt to transmit the disease from one individual to another than are larvae or eggs.

The stage in which the highest per cent of individuals became infected was the third instar of the grub, in which infection was necessarily contracted from the soil, which is believed to have contained large numbers of spores.

The degree of susceptibility to infection by the disease was, among the immature stages of the beetle, lowest in the pupal stage and highest in the third instar of the larval stage.

The following conclusions have been reached regarding attack of

* The habits of this species, and suggestions for control, were discussed in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42–47), under the name *"Lachnosterna grande,"* and its life-cycle (except pre-oviposition) given in the Fourth Report (p. 47) under the same name.

May-beetles by *Metarrhizium*, as result of the behavior of the fungus in its attack on *Phyllophaga vandinei*:

(1) Judging from its behavior in jars containing numbers of adults confined together, the fungus had every appearance of being transmittable.

(2) In jars containing only two adults, the fungus gave no indication of being transmittable. Out of 25 such jars in which at least one beetle contracted the disease, in only two (or 8 per cent of them) did both beetles of a pair become infected.

(3) In the case of grubs, transmission of the fungus from one grub to another was not possible, since practically all of the grubs that became infected were reared in individual boxes. Infection must have taken place through the soil.

(4) Comparing the infection of adults and of third instar grubs, it appears that a higher degree of infectation may be brought about through the medium of infection from the soil than through transmission of the disease by contact. There is no proof that transmission by contact ever takes place.

(5) Attempts to artificially infect grubs by the introduction of dry spores into rearing boxes were unsuccessful.

(6) Since all infected specimens, when found, were at once removed from rearing boxes and preserved, artificial increase of the number of spores in the soil used was certainly very limited. It obviously required a very small quantity of the spores to infect a large number of grubs and beetles.

(7) Spores were at no time introduced into the soil by the writer, so must have existed naturally in the soils of the district where the experiments were made. This was proved by the finding, outside the insectary, of the following insects infected with the fungus:

Aphodius sp., two adults under manure in stock lot.
Canthon sp., a dozen or more adults in an outdoor cage.
Strategus titanus, one adult in an outdoor cage.
Ligyrus tumulosus, several adults in an outdoor cage.
Phytalus insularis, several grubs in an outdoor cage.

(The last four species were in separate cages, removed some feet apart, with no intermixing of soil from one to another.)

(8) Shipments of *Metarrhizium* spores were made by Mr. Van Dine, in 1911 and 1912, to Mr. T. C. Murphy of Guánica Centrale, who propagated the fungus extensively on May-beetles in the same *hacienda* (Santa Rita) where the writer's experiments were conducted. Later shipments of spores to the same district were also made by the pathologists of the Station, Mr. Johnson and Mr. Stevenson. This may have accounted for the prevalence of the disease in the insectary.

(9) Neither in grubs nor adults was there, ordinarily, any sickness or other visible abnormal condition immediately preceding death. Often grubs in perfect condition would succumb to the disease in a week's time or less, making it appear that death was caused by the disease alone.

(10) In some cases infection was aggravated by previous attack of the grub by mites or bacterial disease. In case of the latter, the dead grub usually became only in part infected by the fungus, as though the latter were a saprophyte, whereas in grubs perfectly healthy before infection the entire body became covered with mycelium, and later with spores, following death.

(11) Normally, the disease had the effect of delaying molting, or pupation, thus lengthening the instar. The exceptions were: two grubs in first instar that died respectively four and twenty-six days after hatching from eggs; and six grubs in third instar that died within three months after last molting (one in thirteen days and one in two weeks).

(12) In the case of several grubs that died of this disease, it was noted that the preceding instar was above normal in length, indicating that a rather long period of infection by the disease precedes the outward and visible signs of disease.

Infection of Grubs by Bacterial Disease.

A very high fatality of grubs in the experimental boxes was caused, or had every appearance of being caused, by a bacterial disease that is supposed to be identical with a disease described as *Micrococcus nigrofaciens* by Zae Northrop. (See Technical Bulletin No. 18, Michigan Agr. Sta,. entitled, "A Bacterial Disease of June Beetle Larvae, *Lachnosterna* spp.") The symptoms of the disease are a turning black, and final dropping off, of one or more of the legs at the joints, and the appearance on the body or head of black, shining spots, or lesions, which increase slowly in size and may cover considerable portions of the body before death finally ensues. These symptoms, as observed in grubs in rearing boxes at Santa Rita, are identical with those described in the bulletin by Miss Northrup. Further reason for believing the two diseases identical may be found in a paragraph of that bulletin, which states: "One hundred per cent of larvae received from Porto Rico (March, 1914) were more or less infected."

After examination of the breeding notes, a careful compilation was made of the data concerning the infection of sugar cane white-grubs (*P. vandinei*) by this disease, and as result it was found that sixty-two grubs were noticeably infected, of which number only three pupated and became adult in spite of the disease. The other fifty-nine died, apparently as a result of the disease.

Only the larval stage is attacked by the disease, eggs, pupae and adults being apparently immune. Of the sixty-two larvae attacked, fifty-nine were in the third instar (which represents 50 per cent of the total number reared), and only three in the second instar. No grubs of the first instar were at any time observed attacked by this disease. This is somewhat at variance with the remark made by Miss Northrup that the younger grups are the more susceptible.

It is notable that at no time were grubs collected in the cane fields, or elsewhere out-of-doors, found affected by this disease. Yet within a few weeks' time after they were placed in the confinement of boxes, the disease would make its appearance on fifty per cent of the grubs. This

may have been due to one or more of three causes: (1) that the soil used in the experiments contained the disease to an extent above normal; (2) that the confinement produced a predisposition to the disease through mechanical injury, since it is supposed to require an abrasion of the skin in order to permit the bacteria to gain access to the grub's body; or (3) that excessive humidity in the boxes was favorable to the progress of the disease.

The fifty-nine grubs that died in experimental boxes apparently as a result of the bacterial disease were divided into four groups, as follows:

(1) Grubs with sure signs of infection, that died while still in the larval stage.

(2) Grubs with lesions, or other signs of the disease, that reached the pupal stage and then died.

(3) Grubs with lesions or other signs of disease that died, but were also infected with *Metarrhizium* fungus, so that the exact cause of death was uncertain.

(4) Grubs that showed a characteristic blackening of segments after death, but of which no previous symptoms had been noted.

Of these four groups, forty-five of the grubs fell in the first, four in the second, six in the third, and four in the fourth.

Some idea of the progress of this disease, prior to death of the grub, may be gained by the following records of ten individual infected grubs:

(1) Jan. 18.—Lesion of 1½ mm. on side.
Feb. 3.—Pupating; lesion is 2 mm. across.
Feb. 8.—Pupated. (Adult issued March 3.)

(2) Feb. 17.—Has black lesion 1½ mm. in diameter.
May 26.—Same lesion now 2 mm. across; another lesion of 7 mm. Grub died as result of these.

(3) June 2.—Two right legs with bacterial lesions.
June 30.—Three legs on opposite side now infected.
Aug. 14.—Grub died; discolored.

(4) June 2.—Right middle leg infected at tip.
June 30.—Same leg half off.
July 3.—Tip of left middle leg infected.
July 7.—Tips of all legs but one infected.
July 26.—Preparing to pupate; sickly.
Aug. 5.—Died without pupating; infected with *Metarrhizium*.

(5) May 3.—Has one leg with hacterial lesion.
June 7.—Pupated; pupa with tarsi of that leg missing.
June 25.—Pupa died.

(6) Feb. 5.—Has four small black lesions.
May 26.—Three legs infected, a fourth half eaten off; a lesion of 2½ mm.
May 30.—Grub dead, discolored.

(7) Feb. 18.—A lesion 1½ mm. one one side.
May 26.—Lesion is 2 mm. in diameter.

June 30.—Two more lesions of 2 mm. on other side.
Aug. 5.—Dead and black, including head.
(8) May 26.—Tip of one leg with bacterial lesion.
July 7.—Half of same leg off from disease.
Aug. 21.—Grub dead and discolored.
(9) June 28.—Grub pupating; left middle leg eaten off.
July 2.—Pupa has a left leg, but small.
July 20.—Adult issued, imperfect; died.
(10) June 27.—Grub has lesion on head; two back legs infected (2d instar).
July 5.—Has molted to third instar; two back legs smaller.
Dec. 11.—Grub dead; discolored.

This bacterial disease can hardly be considered as possessing any great possibilities as a means of artificial control of white-grubs, for as seen by the observations cited above, its action in producing death of the grub is slow, requiring in some cases months, under conditions that may be considered ideal for its development. Whether it ever produces fatality of grubs on a large scale in the fields in Porto Rico, at such times as during periods of heavy rainfall, as it is credited with doing in some sections of the United States, is a question open to further investigation.

THE COMMON WHITE-GRUB.

Phyllophaga portoricensis N. SP.*

This species is the eastern analogue of *P. vandinei* occurring at the western end of the Island. Its distribution covers approximately the eastern two-thirds of the Island, being defined in the west by a line running more or less north and south through the towns of Vega Baja on the north coast and Ponce on the south. So far as at present known, its eastern limit on the Island is defined by the east coast. Specimens that have been recently collected on the Island of Vieques, adjoining Porto Rico to the east, appear to belong to this species, so far as genital characters show, though being somewhat larger and lighter in color.

In spite of its wider distribution, this species has not gained as a pest the prominence of the preceding. Damage by it, while most accentuated in the sugar plantations, is by no means confined to them. Its grub is particularly injurious in coffee groves and pineapple plantations. As pines are usually not plowed up until some time after the main crop is harvested, damage from white-grubs may often go unnoticed, or be attributed to poor soil. We have received fre-

* This species has been mentioned, as a supposed variety of *P. vandinei*, under the name of "*Lachnosterna grande* (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

quent reports of pineapple fields turning yellow in spots, and when the plants were uprooted the soil was found to contain many white-grubs, which turned out to be the larvae of this species. Coffee groves are subject to attack of this May-beetle due to the fact that they are grown under shade of certain forest trees, the foliage of which is much relished by the beetles. After feeding, the beetles descend to the coffee trees beneath the larger shade trees, burrow down into the soil in great numbers at their bases and there deposit the eggs. Naturally, the eggs are found, and the white-grubs that hatch from them do the damage, in whatever locations the beetles descend into the ground. One of the principal shade trees of coffee is the "guamá" (*Inga laurina*), and its foliage is often badly damaged by May-beetles of this species. Mr. Van Dine in a note of April 27, 1912, reports the finding of seventy-four May-beetles at the base of a "guamá" tree in a coffee grove, and one hundred and sixteen beetles at the base of one coffee tree near by. It is not uncommon to find thirty or more May-beetles of this species at the base of a coffee tree. The beetles do not feed upon the coffee foliage, but that fact does not, however, prevent the larvae from attacking the coffee roots.

In sugar plantations, this species has been known to do local damage, sometimes even extensive damage, particularly in the Fortuna and Aguirre districts, and at Humacao, Fajardo, and Canóvanas. No doubt there has been damage in other districts, not so far reported. Outbreaks to an injurious extent seem however to be sporadic, and in none of the infested districts mentioned has attack been so severe as to necessitate the continued employment of women and boys to gather the grubs and beetles, as is done in the Guánica district in the case of the preceding species.

The Beetle.

The adult very closely resembles that of the preceding species, but is usually somewhat greater in size (averaging 1 to 2 millimeters more in length), darker in color, and with the surface somewhat polished. In these characters it varies greatly. It is at once distinguishable, in the male, by the sexual characters given in the table; i. e., in the adnate armatures of the male genitalia being spatulate at the tip where in *P. vandinei* they are bifurcate.

Like the preceding, the adult of this species may be found in the field during eight to nine months of the year. It appears the latter part of February to early March, and disappears during November. Stragglers are occasionally found in the winter months.

LIFE HISTORY.

While the life-history of *Phyllophaga portoricensis* has not been studied to the extent and with the thoroughness of the preceding species, such studies as have been made clearly indicate that the entire generation of the species is passed in one year, and that there is sufficient variability in the length of life-cycle to give rise to a considerable overlapping of broods, if indeed the species may be said to have broods. The seasons of appearance in abundance seem to depend largely upon conditions of rainfall, which would indicate that the stage of the life-cycle displaying the greatest variation in length, next to the third instar of the grub, is the period during which the newly issued adult is in the pupal cell in the soil, awaiting the proper soil conditions (i. e., of moisture) to dig to the surface and emerge for feeding and egg laying.

A single individual of the species was reared through from egg to adult, requiring for the transformation (from date of laying of egg to date of issuing of adult) two hundred and seventy-six and a half days.

The average time required to undergo these transformations, found by adding together the averages for the several stages of the insect, each secured from a number of records, was 296½ days; the maximum duration, by adding together the maximums of each stage, 343 days; the minimum, 268 days. Reduced to months, these figures show an average egg-to-adult period of approximately 10 months, a maximum of 11½ months, and a minimum somewhat under 9 months. If larger numbers of individuals had been reared through the various stages, the latitude of variation would undoubtedly have been increased.

The Egg Stage.

The description of the egg and the method of laying given for the sugar cane white-grub (*P. vandinei*) will serve equally well for this one.

The average length of the egg stage (from date of laying to date of hatching), from records of the hatching of fifty-four eggs kept in confinement, was computed to be 13½ days, with a maximum period of 16 days and a minimum of 12 days. The length of this stage is practically the same as for *P. vandinei*.

The White-Grub, or Larval Stage.

The average duration of the larval stage of *P. portoricensis*, obtained by adding the average lengths of the three instars, proved

to be 262 days, which lacks four and a half days of being the same as the recorded average duration of the larval stage of *P. vandinei.*

The lengths of larval stages of two individuals reared through from egg to pupa were, respectively, 242 and 252 days, both below the average for the species.

The First Instar.—This instar of the grub, computed from six records, had an average duration of 32 days, a maximum of 40 days, and a minimum of 26 days. During this instar the grub increases in length from about 6–7 millimeters, when first hatched, to 18 or 19 millimeters at the end of the instar. The breadth of head varies from 1.9 to 2.1 millimeters.

The Second Instar.—This, computed also from observations of six individuals, had an average duration of 61 days, a maximum of 93 days, and a minimum of 43 days, which makes the second instar of the grub of this species appear to be much longer than the corresponding instar of the sugar cane white-grub. This is due to the small number of individual records upon which the average is based, two of the six having required in excess of two months (one of them over three months) to pass the instar, which is abnormally long. True averages can be secured only from large numbers of observations, which will require additional study in the case of this species. The average length of instar from four records not exceeding two months in length was 50 days, which is nearer a correct average.

In length the grub increases, during the second instar, from about 18 to 30 millimeters, and the head varies in breadth from 3.3 to 3.6 millimeters.

The Third Instar.—This instar of the grub, as in the case of the preceding species, is taken as including the pre-pupal stage and is figured as the time elapsing between the second molt and the date of pupation. The pre-pupal stage seldom exceeds a week in any of the Porto Rican species of *Phyllophaga.*

The average duration of the third instar, from records of two reared grubs, was 169 days. The time required by each of the grubs was respectively, 164 and 174 days. To gain accurate knowledge of the average duration of this instar will require the rearing of additional grubs in confinement.

The length of grub increases in the third instar from about 30 to 46 millimeters, and the head varies from 5.5 to 6.2 millimeters in breadth. The average breadth of head, computed from seventeen grubs of an average length of 39 millimeters, was 5.78 millimeters.

Pupa, and Pre-emergence of Adult.

The length of duration of the pupal stage of six individuals, was observed and recorded, the average from them being 20.9 days. The maximum was 23 days, the minimum 19 days. The average measurements, from nine pupae, were as follows: length, 27.72 mm.; width at middle, 12.14 mm.; breadth of head, 6.8 mm. It will be seen from these figures that the pupa, like the adult, is somewhat larger in size than that of *P. vandinei.*

We have not as yet secured figures to show the average length of time spent by the adult of this species in the pupal cell, following its issuing from the pupa, before it digs to the surface of the ground. In all probability the time varies from two weeks to a month or more, depending both upon the season of year and the moisture content of the soil. During the winter months the beetle might be expected to spend as much as two or three months in the pupal cell before digging to the surface.

Feeding Habits of Adult.

The feeding habits of adults of this species, and their preferences as to food plants, correspond exactly with those of its near ally, *P. vandinei.* The beetles feed upon the foliage of a rather wide range of plants, but show decided preference for certain species. Some of these, as for instance, the banana, casuarina, or flamboyant trees, may be almost stripped of foliage by the beetles. Other trees, of larger size or with heavier foliage, such as the almendro, guamá, coconut, breadfruit and trumpet tree, may have the foliage badly eaten, but do not show the injury so much as do the species first named. Some other trees observed or reported to be fed upon to an injurious extent by May-beetles are: bamboo (*Bambusa vulgaris*), avocado (*Persea gratissima*), achiote (*Bixa orellana*), cacao (*Theobroma cacao*), guano (*Ochroma lagopus*), roseapple (*Jambosa jambos*), mango (*Mangifera indica*), and mamey (*Mammea americana*), though it has not been definitely ascertained in every instance whether the species doing the damage is this one.

Besides the trees named above, and those previously mentioned of *P. vandinei,* the following plants are fed upon to some extent by this species: *Ficus laevigata, Cordia corymbosa, Cordia borinquena, Albizzia lebbek* and the corozo palm (*Acrocomia media*). Grasses, aside from cane, are not as a general rule eaten. Sugar-cane foliage, though sometimes showing injury from their feeding, is not as a usual thing noticeably damaged, except where other and more palatable foliage is not near at hand.

A strange thing regarding the feeding habits of this species, which has been noted, is that the adults are often found in abundance in the soil at the bases of trees and weeds upon which they do not feed, such as coffee or young citrus trees, or beneath the wild berengena (*Solanum torvum*), while on the other hand they are seldom found at the bases of certain trees the foliage of which they are very fond of, such as banana and coconut trees. This is not due to a deliberate choice of the beetles as to the kind of roots among which to deposit their eggs, but is explained by the fact that the beetles, before retiring to the soil for the day after feeding, take flight and alight upon small trees or weeds, or upon any upright object affording them good foot purchase, down which they crawl to the soil and enter it. Their holes are thus often found around the bases of posts and dead weeds. Banana trees are too smooth to offer good foot purchase, hence are not settled upon; and coconut palms are provided with a heavy abutment of closely interwoven roots at the base that prevent the beetles from reaching the ground from them.

Among trees and plants that are much fed upon by adults of *Phyllophaga citri,* but are shunned by this species, may be mentioned orange, grape-fruit, Acalypha, Grevillea, guava, Lantana, Miconia, Clidemia, Triumfetta and Urena.

Flight, and Attraction to Light.

The adults of this May-beetle begin coming forth from the soil very soon after dusk, and before actual darkness. As observed in a large outdoor rearing cage during the month of September, the flight may be said to begin at 7:05 P. M. and to last approximately three quarters of an hour.

The following observations were made on an evening of September first: The first beetles appeared above ground and took wing at 7:05 P. M., and they continued to increase in number until 7:20, then remained heavy in flight until 7:35. A few beetles were still flying when observations ceased at 7:50 P. M.

The adults are occasionally attracted to street lights, but only rarely are more than three or four found around a light at one time. On only one occasion has the writer observed an exception to this rule. On April 15 of the present year, around a strong arc light on the *carretera* at Martín Peña, near Río Piedras, over two hundred adults of this species were observed on the pavement, as late as midnight. The probable cause of their abundance was the close proximity of a number of large laurel trees (*Ficus nitida*), upon which the beetles had perhaps been feeding before the turning on of the street lamps.

Copulation and Oviposition.

Copulation takes place immediately upon the cessation of flight, and before feeding begins, normally between 7:30 and 8:15 P. M. In rearing cages it takes place a little earlier, because the flight lasts a shorter length of time than under outdoor conditions. Copulation lasts about thirty minutes.

In the same cage in which the observations on flight were made, the following notes were recorded on an evening of September 2: Quite a number of females were seen at about 8:40 P. M., resting both on the screening and on foliage with the genitalia protruded, in receptive condition. The scarcity of males in the cage accounted for the fact that no copulation was seen. Beetles remain quiet in this position for some minutes before they begin feeding.

Experiments to determine the rate of egg laying of this species are in progress, but have not been completed. The beetle's life above ground is believed to last normally between two and three months, and the egg-laying period to cover in the neighborhood of a month.

Insect Parasitism.

The insect parasites of this May-beetle are identical with those of *P. vandinei*, the Tachinid parasite *Cryptomeigenia aurifacies* Walton being the most useful parasite of adults, and the predacious wireworm, *Pyrophorus luminosus* Illiger, the most efficient insect enemy of the grubs. These two parasites are very doubtless responsible, in large measure, for the fact that this May-beetle has not caused the disastrous and widespread damage to sugar-cane properties on the north and east coasts that *P. vandinei* has caused in the Guánica district, where neither of the two parasites occur.

Unfortunately, all of our notes relating to the Tachinid parasite *Eutrixoides jonesii* Walton, which were made previous to 1916, fail to indicate what species of *Phyllophaga* were the hosts, since at that time the different species were not distinguished. Necessarily, in the Añasco district the host was one of the two species *P. vandinei* or *P. citri*, or perhaps both, and in the San Juan district must have been either *P. citri* or the present species, if not both. Further observations will be necessary to determine the exact host of this fly.

A Scoliid wasp known as *Elis xanthonotus* Rohwer, the female of which is black with a red spot on the thorox and the male black with yellow cross bands, found very commonly in the fall in the vicinity of Río Piedras, may prove to be a parasite of this species or of *P. citri*, or both. Observations have not thus far revealed the host of the wasp.

Attack by the Metarrhizium Fungus.

The only stages of *P. portoricensis* which have been recorded attacked by the green muscardine fungus are the adult and the third instar of the larva. From the rearing jars and boxes have been taken at different times, altogether, thirteen adults and two grubs attacked by the fungus. The infected adults all came from two jars, each of which contained a good number of specimens, which would seem to indicate that the disease had been communicated from specimen to specimen. The grubs, on the other hand, were from individual boxes, and seem to have contracted the disease from the soil, which, there is reason to believe, contained an abundance of spores of the disease.

Of a total of twenty-four grubs reared past the first instar in confinement, the death of two by the disease represented an infection of 8 per cent. This may have been higher, as grubs were often preserved in alcohol immediately after their death, giving no chance for possible development of spores of the disease.

The per cent of infected adults, to the total number kept in confinement, was still higher than of grubs, but there is no reason to think that such a fatality results from the disease under normal outdoor conditions, since adults showing the disease have been very rarely found in the field.

THE SOUTH COAST WHITE-GRUB.

Phyllophaga guanicana n. sp.*

This species derives its name from the locality in which the type specimens were collected, namely, the Guánica District of the southwest coast of the Island. So far as observations inform us, to date, the species is peculiar to that district.

As a cane pest, it is of comparative unimportance beside the larger species (*P. vandinei*) frequenting that district. Yet it must be included among the pests of sugar cane, since the grubs occur to a certain extent in the cane fields among those of the commoner species. In the nightly collections of May-beetle adults that are made by boys employed for the purpose there is usually to be found, during the months in which the species is active, a small proportion of adults of *P. guanicana*. Actual counts made by the writer in 1914, at weekly or semi-weekly intervals for a period of three months (from the latter

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (pp. 42–43), under the name of "*Lachnosterna* media," and a summary of its life-cycle (except pre-oviposition) given in the Fourth Report of the Board (p. 47) under the same name.

part of March to the latter part of June), of the entire nightly collections made by the beetle pickers in cane fields, showed that less than one per cent of the May-beetles collected from sugar-cane foliage belonged to this species, the remainder being adults of the common sugar-cane white-grub (*P. vandinei*).

The following table, which is reprinted (revised) from the Third Report of the Board of Commissioners of Agriculture (page 43), gives the actual numbers of beetles of the two species collected on the various nights:

Santa Rita, 1914	*P. guanicana* n. sp.	*P. vandinei* n. sp.
March 30	32	2,968
April 1	12	2,868
" 6	80	3,226
" 13	9	3,188
" 20	40	2,690
" 28	43	2,692
May 17	5	1,279
" 24	12	1,838
June 1	5	2,181
" 8	0	2,384
" 14	1	1,322
" 21	1	1,655
Total	240	28,291

The period of activity of adults of this species is much shorter in duration than that of *P. candinei*. Appearing at about the same time of the spring, during the latter part of February, it reaches a maximum abundance about middle April to early May, then begins to decrease in numbers and entirely disappears from the fields by the middle of July. In fact, usually only a few are to be found after the middle of June. Having a life-cycle of one year, like *P. vandinei*, it is hard to account for the fact that this species confines its appearance in the adult stage to a short season of the year.

Collections of adults recently made by the writer at Yauco and Santa Rita on May 3 and 4 have shown that this species, outside of cane fields, is equally abundant to *P. vandinei* in the Guánica district in the spring of the year. It was noticeable, however, that the beetles fed largely upon trees and plants not frequented by the larger species. They were particularly abundant on the foliage of *Lantana camara*, the black sage (*Cordia cylindrostachya*), and the ucar tree (*Bucida buceras*), all of which grow in the upland, along fences or scattered through pasture land, and none of which are extensively fed upon by *P. Vandinei*. This leads to the belief that the grub of this species is a sod-frequenting one, preferring dry upland soils, and has not yet taken to the cane fields to any extent.

The Beetle.

This species is very easily distinguished from *P. vandinei* by its smaller size and somewhat darker color. The largest individuals are smaller than the smallest of *P. vandinei*. In length the adult varies from 13 to 17 millimeters, in width from 7 to 8½ millimeters. The average length is about five-eighths of an inch.

The thorax of the beetle, in both sexes, is polished, rich mahogany brown; the elytra are somewhat paler, and polished in the female, but covered with a very fine plumbeous pubescence in the male. The species is very readily distinguished from *P. vandinei* by an examination of the genital organs of either male or female. The characters by which the two are separated are given in the table in the preceding part of this paper, and are quite clearly shown in the plate.

Life-History.

This species has received more study in the immature stages than any other, next to *P. vandinei*, due to its occurrence in the Guánica district, where the South Coast Laboratory was located and where most of the white-grub studies and experiments were conducted. Prior to the work done by the writer, the presence of this species in the Guánica district as distinct from *P. vandinei* seems to have been overlooked, as there is nothing in the earlier notes to indicate that two species occurred together there, and no specimens of the species were in the collection of the Experiment Station.

The life-cycle agrees in a general way with those of the two preceding species in requiring one year. The immature stages require approximately nine months.

For some unaccountable reason, while a large number of the larvae, or grubs, of this May-beetle were reared successfully to past the middle of the third instar, only four individuals were successfully reared to the adult. Two others successfully reached the pupal stage, but a great majority died in the latter part of the third instar. Most of the fatalities occurred within a single week of the summer, and it is believed that the tin boxes, in which the grubs were being reared, were allowed to become too hot from resting against a side of the building exposed to the sun.

Of the four individuals reared through from egg to adult, the shortest required between 226 and 240 days and the longest between 321 and 331 days, which displays a range of duration of from eight to eleven months.

The average duration of the egg-to-adult period, obtained as a

sum of the averages of the egg, pupa and separate instars of the grub, amounted to 268½ days, with a maximum of 336 days and a minimum of 207 days. Reduced to months, this gives an average duration of 9 nine months, a maximum of approximately 11 months, and a minimum of 7 months.

It is notable with regard to the life-cycle of this species that no eggs were laid by adults in confinement later than the middle of May, and that all but nine of the total number of eggs were laid in March and April. This shows that individuals requiring the shorter length of time to pass the immature stages would reach the adult stage during the winter months, and would therefore pass the remaining time in the soil as adults until the regular time of emergence (in the latter part of February and March). Those requiring the maximum of eleven months (which would be very few), even though coming from eggs laid in May, would still reach the adult stage the following April, in sufficient time to mate and lay eggs by May again. This may account for the species having but one brood, appearing wholly between February and June.

The Egg Stage.

The egg of this species does not noticeably differ from that of *P. vandinei* except in being smaller. When first laid it is slender, oblong-oval, about 2 mm. in length by 1.2 mm. in breadth, and opaque pearly white in color. At the end of ten days it is greatly swollen and less opaque in color; it becomes nearly spherical, being then about 2.4 mm. in length by 2.2 mm. in diameter. Just before hatching, the brown mandibles and the segmentation of the young grub become plainly visible through the shell of the egg.

The duration of the egg stage, from an average of 505 eggs whose hatching was observed in confinement, amounted to 13½ days. The maximum duration was 19 days; the minimum, 11 days.

The White-Grub, or Larval Stage.

As in other May-beetles, the larval period of this species includes four distinct stages: the first, second and third instars, and the pre-pupal stage. Between the first and second instars, and again between the second and third instars, there is a molt of the larval skin, following which the head and legs of the grub increase very perceptibly in size. At the end of the pre-pupal stage there is also a molt, to form the pupa. There is no molt between the last instar of the grub and the pre-pupal stage, and the change from one condition to the other is quite gradual. This change in condition does not take place until

a week to ten days immediately preceding the pubation of the grub. In our figures, therefore, the pre-pupal stage is considered as included in the third instar of the grub.

The average duration of larval period from the sum of the average lengths of the three separate instars, was 233 days; the maximum, 295 days; the minimum, 174 days. Reduced to months, this gives an average duration of 7¾ months, a maximum of 9¾ months, and a minimum of 5¾ months.

The average length of the larval stage, obtained from the six individual grubs that successfully reached the pupal stage, was 245 days, which was twelve days in excess of the average for the species. This was due, it is believed, to the fact that the soil in the cage in which these five grubs were reared was allowed to become very dry at times, for periods of weeks, which retarded the growth of the grubs to a marked degree.

The First Instar.—The average duration of this was 24 days, the maximum 35 days, and the minimum 13 days, computed from a total of sixty records of reared grubs.

In measurement, the first-instar grub varies in length from about 5 millimeters, when first hatched from the egg, to a maximum length of 12 or 13 millimeters.

The average diameter of the head, from measurements of thirty-two grubs whose average length was 11.3 millimeters, was found to be 1.33 millimeters.

The Second Instar.—The average duration of the second instar was found to be 31 days, or just a month; the maximum 39 days; the minimum, 23 days. These figures are from the records of thirty-eight individual grubs reared through this instar.

The length of the grub in the second instar increases from 12 or 13 millimeters just following the molt, to a maximum of 20 or 21 millimeters. The average width of head, from measurements of thirty-three grubs whose average length was 15.7 millimeters, was found to be 2.38 millimeters.

The Third Instar.—The average length of the last instar, taken from six grubs that reached the pupal stage, was found to be 178 days; the maximum, 221 days; the minimum, 138 days. Or, reduced to months, the average was 6 months, the maximum 7⅓ months, and the minimum about 4½ months.

In length, the third instar grub increases from about 20 to about 31 or 32 millimeters. The average width of head, from measurements of five grubs whose average length was 25 millimeters, was found to be 4.09 millimeters.

From the above measurements of grubs, it will be seen that larvae of this May-beetle may be at once distinguished from those of *Phyllophaga vandinei,* in whatever instar, by simply measuring the diameter of the head with a sliding callipers. Furthermore, by means of the head measurements and a consideration of the locality, the grubs of any of the five species of May-beetle occurring on the Island may be easily distinguished, one from the other, without the need of laboriously studying minor characters, which at best are variable.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage of *Phyllophaga guanicana* was determined as 22 days, recorded from a single pupa. The measurements of this pupa were as follows: length 18 millimeters; width at middle, 7.9 millimeters.

The pupa may be very readily distinguished from that of *P. vandinei* by its smaller size, and its somewhat darker color.

As has been stated before, the length of time spent by the adult of this species in the pupal chamber before emergence is supposed to very often exceed a month, and may perhaps, in cases where the adult issues during November, approach or even exceed three months. No experiments were conducted to determine this fact. In confinement, however, three adults issued during late November and early December; and it is well known that in the field beetles of this species never emerge from the soil during these months.

Food Plants of Adult.

This species, as was mentioned in the beginning, frequents the dry upland pastures and brush land, and is not often encountered in cane fields. It is natural, then, that its food plants should differ considerably from those most palatable to the sugar-cane May-beetle (*P. vandinei*). Among the few trees upon which both species are known to feed may be mentioned the flamboyant, casuarina, salcilla (*Schrankia portoricensis*), guacima, and tamarind.

Among those trees and bushes which are fed upon peculiarly by this species, and are rarely or never eaten by the sugar-cane May-beetle, are the guava (*Psidium guayava*), the ucar tree (*Bucida buceras*), the black sage (*Cordia cylindrostachya*), *Lantana camara* and *Hamelia* sp. All of these are favorite food plants of the beetle.

Flight and Attraction to Light.

The flight of this species was observed in a rearing cage at Santa Rita on April 28, 1915. The first beetles took flight from the soil

at 7:06 P. M., the flight was at its height at 715, and ceased at about 7:26. The duration of flight was thus twenty minutes. Perhaps it would be somewhat lengthened under outdoor conditions, with no screening to confine the radius of flight.

No tests were made to determine the usual distance of flight, but it is probably limited largely by the proximity of agreeable food plants, as is the case with the larger species.

This species has the habit, common to all of the May-beetles, of flying to lighted lamps and electric lights in the early evening. At Santa Rita, where the experiments were conducted, it was less commonly taken at light than the larger species, even during its season of greatest abundance, from March to June.

Copulation.

Records of the time and duration of copulation were made on the same night as the flight observations. The time of joining and separating of three pairs was as follows: (1) started 7:17, ended 8:05, lasted 48 minutes; (2) started 7:22, ended 8:14, lasted 52 minutes; (3) started before 7:24, ended 8:12, lasted over 48 minutes.

From these it appears that copulation usually takes place, at this time of year, between the hours of 7:15 and 8:15, and has an average duration of about three-quarters of an hour.

Oviposition.

To determine the length of life of the adult, the length of egg-laying period and the average number of eggs laid by a female, sixteen pairs of adults of this species were confined separately in jars and fed regularly until their death. They were fed upon strips of banana leaf. Twelve pairs were confined on March 19, the other four pairs on April 6. The female of one pair died within three days, so that the records of only fifteen pairs are used in the calculations. The last female died on May 18.

From the fifteen females, the average length of life of the female adult was found to be 36 days. The longest life was 55 days, or somewhat under two months.

The average length of egg-laying period (the time included between the dates of laying of the first and last eggs) was 19.47 days; the maximum, 41 days; the minimum, 2 days.

The average number laid by a female was 15.6 eggs. The maximum number laid by one female was 40 eggs, which were laid in a period of 36 days, a rate of somewhat over 1 egg per day.

The average number of eggs laid per day, for the beetles' whole life, was .51; the average number per day for the egg-laying period only was 1.19 eggs.

The maximum rate of egg laying was 13 eggs laid in one day by one female. No other eggs were laid by the same female within 10 days before or after the date of laying the 13 eggs.

Comparing this species with *P. vandinei*, it will be seen that the average number of eggs per female, and the maximum length of egg-laying period, is about the same for the two.

The average length of life of a female, and the maximum number of eggs laid in 24 hours, is considerably less for this species than for *vandinei*.

On the other hand, the average number of eggs laid per day, and the average duration of the egg-laying period, is noticeably greater for this species than for *vandinei*. The average female of *guanicana* laid eggs at a rate of one every two days; the average female of *vandinei* laid at the rate of one every three days.

Insect and Fungus Enemies.

No insect parasites or predacious enemies are yet known to prey upon this May-beetle or its larva.

The stages of this insect that became infected by the green muscardine fungus in experimental boxes were as follows: Eight eggs, one grub of first instar, one grub of second instar, and nine (or probably more) adults. The hightest per cent of infection was among the adults; the next highest among the eggs. No grubs of the last instar were recorded as infected by the fungus.

THE CITRUS WHITE-GRUB.

Phyllophaga citri n. sp.*

This species receives its name from the fact that, although it feeds upon a large variety of plants, it is distinctly an inhabitant of the citrus orchards, and its larva is a pest that often gives much trouble to young citrus trees. The damage the grubs do to older trees is usually not known, and goes unheeded because of the greater ability of older trees to stand the reduction in feeding roots caused by the grubs. Young trees quickly show the damage of the root trimming done by the grubs. Inquiries that have been made of citrus growers

* This species has been mentioned as a supposed variety of *P. guanicana*, under the name of "*Lachnosterna* media (northern form)," in the Fourth Report of the Board of Commissioners of Agriculture of Porto Rico, page 48.

over much of the north and west sides of the Island as to the presence of this May-beetle in their orchards, and the damage done by it, have in many instances brought reply that the damage is considerable, and that little can be done to prevent it, except picking the beetles or grubs by hand or spraying with arsenate of lead. These are said to give only temporary relief.

While grubs of the two larger species, *vandinei* and *portoricensis*, may also be found to some extent at the roots of citrus trees, their occurrence is usually accidental. Adults of these species feed rarely if ever upon citrus foliage, and consequently do not often seek the soil at the bases of citrus trees to lay their eggs.

The citrus white-grub is also a pest of sugar-cane, of pasture grass, and of a variety of other crops. The grubs are sometimes found as abundantly as those of the larger species in cane fields that are being plowed. It is therefore quite as important a general crop pest, in some localities, as either the common or sugar-cane white-grub.

Distribution.

This seems to be the most widely distributed species of *Phyllophaga* occurring on the Island. Specimens have been collected at Mayagüez on the west coast, along the entire length of the north coast from Aguadilla to Fajardo, at Lares, Utuado, Aibonito, Cayey, and other towns inland, and on the south coast from Aguirre eastward. Specimens have also been collected on the Island of Vieques, to the east of Porto Rico.

The type of this species is from Río Piedras, in the San Juan district, which is midway (or a little east of midway) of the Island on the north coast. Specimens from other localities do not seem to vary much from the type, though it is possible that future study will reveal the presence of sub-species.

On Vieques Island, where sugar cane is the principal crop, this species is less abundant than *portoricensis*, and therefore less important as a pest.

The Beetle.

Superficially, this May-beetle very closely resembles *P. guanicana*. The average size is a little larger, about one millimeter more in length. As in that species, the elytra of the male are covered with a very fine, plumbeous pubescence, that makes it duller in color than the female. The latter differs from the female of *P. guanicana* in having the elytra, instead of uniformly polished over the surface, polished only on the disc back of the middle, while the sides and fore-part

of the elytra are plumbeous as in the male. This character may vary somewhat in individuals of any one locality, but is fairly constant for the species, from whatever locality.

The sure character by which to distinguish this species from *P. guanicana* is in the male genitalia, which has been figured in the preceding section of this paper. That part of the medium lobe of the male genitalia which has been called the spatha is depressed, chitinized and polished above, and unsymmetrical, being curved or hooked upward on the left side, where it terminates in a serrated edge.

The spatha of the male genitalia of *P. guanicana*, on the other hand, is thicker vertically than horizontally, is bilaterally symmetrical, and is fleshy except for two rows of minute, brown, prostrate spinules (directed forward) that form a V on the dorsal surface, and two similar rows, or edges, of spinules on the ventral surface.

Life-History.

Insufficient work has thus far been done on the life-history of this species to warrant saying more than that it is very similar to that of *P. guanicana*. It probably differs in no essential detail.

While the adults of this species appear in the earliest spring (in the last days of February) their occurrence seems to extend over a greater portion of the summer than does that of the other species, for specimens may be found even as late as October.

THE EGG.

In size and appearance, the egg does not differ from that of *P. guanicana*, which has been described. The average length of the egg stage, from a large number of observations, was ascertained to be 12.88 days, or practically 13 days, which is about the same as the egg stage of the other small *Phyllophaga*.

THE WHITE-GRUB, OR LARVAL STAGE.

The ascertained length of the first two instars of the grub was the same as for *P. guanicana*, and it may be expected that the last instar will also prove the same.

First Instar.—From three grubs carried through this instar, the average duration was 24 days, or exactly the same as the duration of that instar in *P. guanicana*. The only recorded measurement of a first instar grub was: length, 13 millimeters; breath of head, 1.45 millimeters.

Second Instar.—This was observed of but one grub, which required from 30 to 32 days between the first and second molts. The measurements of a single grub in this instar were: length, 22 millimeters; breadth of head, 2.65 millimeters.

Third Instar.—The duration of this instar has not yet been obtained. It is doubtless the same as that of *P. guanicana.* The average dimensions of four grubs in this instar were: length, 28 millimeters; breadth of head, 4.4 millimeters.

The Pupa.

The duration of pupal stage, from a single observation, was 23 days. The measurements of this pupa were: length, 20 millimeters; breadth at middle, 9.2 millimeters.

Food-Plants of Adult.

Some of the commoner trees and plants of the north side of the Island upon which this species feeds in common with the larger species (*vandinei* or *portoricensis*) are: flamboyant, casuarina, almendro, bucar (*Erythrina glauca*), quenepa (*Melicocca bijuga*), jobo (*Spondias lutea*), sonnadera (*Albizzia lebbek*), muñeco (*Cordia borinqueña*), and *Cordia corymbosa.* The list is not a complete one, but would include a large number of common forest and fruit trees, on which sufficient observations have not yet been made to know what species attack them.

A few trees and plants on which this species feeds abundantly to the exclusion of the two larger species are: grapefruit, orange, guava, silk oak (*Gravillea robusta*), *Acalypha wilkesiana,* garden rose, *Miconia racemosa, Clidemia hirta, Lantana camara, Triumphetta* spp., and *Urena lobata.* Further observations will lengthen the list.

Habits of Adults.

The attraction of the beetles to light, and the hours of flight and of copulation in the evening, are practically the same as for the adult of the Guánica white-grub. Flight has been observed up to 7:50 P. M., and copulation up to 8:15 P. M.

Studies are being made to ascertain the average length of the beetle's life, the duration of the period of oviposition, and the number of eggs laid by a female, but are not yet complete.

Insect and Fungus Enemies.

Subsequent to the segregation of the different species of *Phyllo*

phaga, no accurate observations have been made as to the parasites peculiar to each species; and the earlier notes of the Station do not in any instance indicate what species were the hosts of the parasites reared. It is possible, however, that both species of Tachinid fly, *Cryptomeigenia aurifacies* Walton and *Eutrixoides jonesii* Walton prey upon the adults of this species as well as upon those of the two larger species of *Phyllophaga*.

The predacious wireworm, *Pyrophorous luminosus* Illiger, is as truly an enemy of this white grub as of the two larger species.

The only stages of the species that have been found infected by the fungus are the egg, five of which were found covered with spores in June, in experimental jars, and the adult.

THE LITTLE BROWN MAY-BEETLE.

Phytalus insularis n. sp.*

This May beetle is so much smaller than the four preceding species as to be at once distinguishable from them, even to the layman. The type specimens of the species are from Santa Rita, in the Guánica district, collected by the writer. The species has also been collected at Añasco, Garrochales (near Arecibo), San Juan, Río Piedras and La Plata, so that its distribution is probably general over the western two-thirds of the Island. Whether it occurs at the eastern part of the Island is not known. More specimens by far have come from the Guánica district than from all other localities combined.

As both larvae and adults have been collected in the cane fields at Santa Rita, this species is considered among the cane pests. It is not, however, of much importance as a pest either to cane or to other crops, because of its scarcity. The mature grub being no larger than the sugar-cane white-grub is at the end of the first instar, it would require ten or more of them to equal in weight one mature grub of the larger species, and the damage committed by each must be correspondingly small.

Usually, among the grubs gathered in the plowed cane fields at Santa Rita by the grub pickers employed by Guánica Centrale, were to be found fewer than a dozen grubs of this May-beetle to each thousand of the sugar-cane white-grub. Often there were none; only certain fields contained grubs of this species. On the occasion when

* This species was first mentioned in the Third Report of the Board of Commissioners of Agriculture of Porto Rico (page 42), under the name of "*Lachnosterna* pequeña," and a summary of its lifecycle (except the pre-oviposition) given in the Fourth Report of the Board (page 47) under the same name.

the largest recorded number of these grubs was taken from a plowed cane field (tablón 21, hacienda Santa María, Feb. 25, 1915), actual count of a pailfull of grubs gave the following results: *Phytalus insularis* (all 3d instar), 38; *Phyllophaga vandinei* (2d and 3d instar), 970.

The Beetle.

The adult is dark, burnished brown with somewhat lighter margins, more noticeable on the thorax. The length varies from 9½ to 11½ millimeters, the breadth about half of that.

While not belonging to the genus *Phyllophaga,* this insect can very rightly be considered a May-beetle, because of its very close relationship to that genus in every particular. In fact, some of the characteristics upon which the genus is founded are so unstable as to cause some specialists to question whether the genus name should be retained. In the writer's opinion the genus is a valid one, because of the marked characters of genitalia, distinguishing it from *Phyllophaga.*

Life-History.

The life-cycle of this species, like the four preceding, covers just one year. In confinement, no grubs were successfully reared to maturity in the smaller boxes, but in a large outdoor cage a large number came through from egg to adult. The eggs from which these came were laid between August 25 and September 25, and the first adults of the new generation were observed in the cage on August 20 of the following year, clearly proving the life-cycle to be one year.

Unfortunately, the soil in this cage was not dug up and examined at the right time of year to find pupae, and preserve specimens of them. The pupa of this beetle is still unknown. On January 19, a part of the soil in the cage was examined, and 60 grubs were found, of which 57 were in the third instar and 3 at the end of the second instar. On April 30 all the soil was examined, and 134 grubs found, all of which were in the third instar, 2 of them dead and covered with *Metarrhizium* spores. No pupae were present at that date.

In the tin boxes, two grubs reached the pre-pupal stage, but both failed to pupate. From them, however, the length of the third instar was ascertained.

If we may estimate the pupal stage of this species as requiring 20 days, adding to this the averages for the other stages and instars, the average duration of egg-to-adult period is found to be 301 days (the same as for the sugar-cane white-grub); the maximum, 316 days; the minimum, 283 days.

THE EGG STAGE.

The average length of egg stage, calculated from the hatching of 146 eggs in confinement, was 11½ days, the maximum 12 days, the minimum 10½ days.

The dimensions of the egg are: when first laid—length, 1.5 mm.; breadth, 1 mm.; when much swollen and shortly before hatching—length, 1.9 mm.; breadth, 1.7 mm.

The eggs of this May-beetle are laid singly in the soil, in tiny pits, of about three times the diameter of the egg, and do not differ in any noticeable detail, except size, from the eggs of *Phyllophaga*.

THE WHITE GRUB, OR LARVAL STAGE.

The larval stage requires, from our figures, an average duration of 268½ days (or about 9 months). The maximum duration, obtained by adding together the maximum lengths of the three instars, was 284 days; the minimum, 252½ days.

No larvae younger than the third instar are found in the fields after the latter part of January; no larvae of the first instar are found after November.

First Instar.—The average duration of this instar, from 30 grubs, was found to be 30 days; the maximum, 39½ days, the minimum, 21½ days. The measurements of the grub in this instar were not obtained, but can be easily estimated from the size of the egg.

Second Instar.—The average length, from records of 10 grubs, was 45¼ days; the maximum, 54 days; the minimum, 37 days. The dimensions of the only second-instar grub measured were: length, 10 millimeters; width of head, 1.5 millimeters.

Third Instar.—The length of the last instar, averaged from but two grubs, was 194 days. One of these required 186½ days and the other 197 days to reach the pupal stage.

Of twenty grubs in this instar that were measured, varying from 16 to 22 millimeters in length, the average width of head was 2.63 millimeters.

PUPA AND PRE-EMERGENCE OF ADULT.

The length of the pupal stage has not been determined, but doubtless requires in the close neighborhood of 20 days.

Pre-emergence in the Guánica district at least, where the adults first appear in the fields in August, probably requires a shorter time than in those species which issue during the cool winter months, and wait until spring to emerge from the soil.

Seasonal distribution.

The season of appearance of the adults seems to vary considerably in different localities. All adults that have been collected at Santa Rita were found between early August and the middle of October. A specimen was collected at Añasco in September.

A number of specimens from La Plata, in the center of the Island, were colilected in the middle of June.

At Garrochales, near Arecibo, the writer collected 35 specimens, on one Lantana plant by the road, on April 26.

Single individuals collected by electric light at San Juan and Río Piedras bear the following dates: June 6, July 4, August 25, October 15, November 8 and December 1, thus covering a range of seven months.

Food Plants of Adults.

At Santa Rita, all specimens collected by the writer were found feeding upon "bledo," or pig weed (*Amaranthus* spp.), or upon "malojillo," or Para grass (*Panicum barbinode*), the majority upon the former. A single specimen was feeding upon "salcilla" (*Schrankia portoricensis*). In experimental cages adults were seen feeding upon corn foliage. No specimens were seen feeding upon cane, though they occurred plentifully in the cane fields, and doubtless the grubs attacked cane roots.

The series of beetles collected at Garrochales were all feeding upon *Lantana involucrata*, though there was a great variety of other vegetables near at hand.

Flight and Attraction to Light.

Flight of the species was observed at Santa Rita in a large rearing cage on the night of September 1, 1914. The first individuals left the ground and took wing at exactly 6:55 P. M. The numbers in flight increased most rapidly from 6:55 to 7:00, and continued heavy until nearly 7:10, then gradually dropped off. By 7:20 flight was quite light, but continued to some extent until 7:30, when a very few were still flying. The last beetle ceased flying about 7:35. Most of the beetles flew against the west side of the cage.

All the specimens of this beetle collected at Río Piedras or San Juan have been taken at light, and a very few were taken at Santa Rita at a large gasoline lamp.

Copulation and Oviposition.

On September 1 these observations were made:

Pairs began mating at 6:57 P. M. At 7:05 over a dozen pairs were mating. At 7:07 pairs were beginning to separate. At 7:15 the majority had separated. At 7:25 the last pair separated.

And on the following evening, similar observations: First pair united at 6:57; largest number copulating, 7:05; last pair separated, 7:28. Total time consumed, 31 minutes.

Exact records of six copulating pairs on the same night were as follows:

(1) United, 6:58; separated, 7:06; time spent, 8 minutes.
(2) United, 6:59; separated, 7:08; time spent, 9 minutes.
(3) United, 7:01; separated, 7:10; time spent, 9 minutes.
(4) United, 7:02; separated, 7:12; time spent, 10 minutes.
(5) United, 7:01; separated, 7:11; time spent, 10 minutes.
(6) United, 7:08; separated, 7:23; time spent, 15 minutes.

Average length of time spent in copulation, 10 minutes.

Those pairs on or near the ground copulated without taking flight. In no case was a beetle seen to take flight after copulation. As with the species of *Phyllophaga*, they immediately begin to feed after copulation; and if resting on a leaf, the female usually feeds during copulation, the male never. About 50 per cent of the beetles copulated without first taking flight.

The females, in the receptive mood, rest with the abdomen slightly raised, and with the genitalia protruded in a conspicuous florescence, which is pale yellow in color and fully three times as great in diameter at the tip as at base. In this position they rest for ten minutes or longer until a male appears.

No females of this species were confined singly to secure eggs. Females were, however, confined in numbers at different times in jars with food to secure eggs. The average rate of egg laying computed from the eggs thus secured was one egg in three days by each female. At which rate, a female living two months would lay only twenty eggs. This figure may not be accurate since, in confining numbers of beetles together, some eggs are necessarily destroyed by the beetles in boring into the soil.

Insect and Fungus Parasites.

No insect parasites have yet been discovered preying upon either larva or adult of this May-beetle.

The only stages of this May-beetle that became infected by the

green fungus were the adults, and grubs of the last instar. No record was kept of the number of adults, but it exceeded a dozen. Of the grubs reared, a rather astonishingly large number became infected, in the jars and boxes, by this disease. Out of 142 third-instar grubs kept in confinement under observation, there is record of 13 becoming infected by this fungus, which is 9 per cent of the total number, a higher per cent than was noted of the grub of any other May-beetle except *Phyllophaga vandinei.*

Summary of Life-cycles and Measurements of May-Beetles and White-Grubs.

THE SUGAR-CANE WHITE-GRUB, *Phylloghaga vandinei* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	16	10	14	1,089	2.97	1.7	.....
Grub, 1st Instar...	59	17	36½	184	6-17	.....	1.94
" 2d " ...	103	26	47	71	16-28	.....	3.32
" 3d " ...	226	78	183	25	27-45	.....	5.31
Pupal Stage. .	26	17	21½	22	23-27	10-12	.....
Total.....	430	148	302	1,391	.....	.....	.....

THE COMMON WHITE-GRUB, *Phyllophaga portoricensis* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	15	12	13½	54	3.0	1.75	.....
Grub, 1st Instar...	40	26	32	6	6-18	.....	2.10
" 2d " ...	93	43	61	6	18-30	.....	3.45
" 3d " ...	174	164	169	2	30-48	.....	5.70
Pupal Stage.	23	20	21½	5	25-29	11-13½	.....
Total.....	345	265	297	73	.....	.....	.....

THE SOUTH COAST WHITE-GRUB, *Phyllophaga guanicana* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	19	11	13½	505	2.05	1.2	.....
Grub, 1st Instar...	35	13	24	60	4½-12	.....	1.33
" 2d " ...	39	23	31	38	12-20	.....	2.38
" 3d " ...	221	138	178	6	20-32	.....	4.10
Pupal Stage.....	(22)	(22)	22	1	18	7.9	.....
Total.....	336	207	268½	610	.....	.....	.....

THE CITRUS WHITE-GRUB, *Phyllophaga citri* N. SP.

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	.....	.....	13	200	2.12	1.25	.....
Grub, 1st Instar...	.....	.....	24	3	5-13	.....	1.45
" 2d " ...	.....	.....	31	1	13-22	.....	2.6
" 3d " ...	.....	.....	(178)	0	22-34	.....	4.4
Pupal Stage.....	.....	.....	23	1	20	9.2	.....
Total.....	.....	.....	269	205	.....	.....	.....

	Maximum	Minimum	Average	Number	Long	Wide	Head
Egg Stage.....	12	10½	11½	146	1.45	.90	.....
Grub, 1st Instar...	39½	21½	30	30	3½-8	.....	.....
" 2d " ...	54	37	45¼	10	8-14	.....	1.5
" 3d " ...	197	191½	194¼	2	14-22	.....	2.63
Pupal Stage.....	(20)	(20)	(20)	0	12¼	5.1	.....
Total.....	322½	280½	301	188	.....	.....	.....

* The columns of figures in the above table (which were all obtained by actual observation or actual measurement), numbered from left to right, may be explained as follows:

(1) Maximum duration in days of the immature stages, the totals being the maximum egg-to-adult period for each species, in days.

(2) Minimum duration in days of immature stages, etc.

(3) Average duration in days of immature stages, etc.

(4) Numbers of eggs, grubs, or pupae, averaged to obtain the figures of the first three columns.

(5) Average length in millimeters of each of the immature stages, taken from a number of measurements made with sliding calipers.

(6) Average breadth in millimeters of egg and pupa of the various species, from measurements with sliding calipers.

(7) Average breadth in millimeters of the head of grub in each instar of the five species, from measurements with sliding calipers.

THE EGGPLANT LACE-BUG IN PORTO RICO.

Corythaica monacha Stal.

By R. T. Cotton, Assistant Entomologist, Insular Experiment Station.

The growing of the eggplant *Solanum melongena,* is made difficult by the ravages of a great many insect pests, the worst of which is undoubtedly the lace-bug *Corythaica mŏnacha* Stal. This bug is widespread over the Island and attacks the eggplant wherever it is grown, causing heavy damage when not controlled by spraying. It feeds normally on the so called wild eggplant, *Solanum torvum,* and it is on this plant that it is able to survive during the intervals between crops. *Solanum torvum* is one of the most abundant of weeds on the Island, growing luxuriantly in all parts and at all times, and it is undoubtedly owing to this fact that the lace-bug is so abundant. If it were dependent solely on the cultivated eggplant for its food supply it would soon die out, but as the eggplant is seldom grown at all times of the year even in the most favorable localities.

The injury to the plant is occasioned by the feeding of the nymphs and adults, which congregating in hundreds on the undersides of the leaves, suck the vital juices from the plant. Their presence on the leaves is first indicated by the appearance of small yellowish-brown patches, which growing in size soon involve the entire leaf causing it to dry up and fall off. It is not an uncommon sight to see a whole patch of eggplant entirely denuded of its leaves. The insect has a very short life cycle and multiplies so rapidly that once introduced into a field it soon spreads to every plant.

Life-History.

This insect breeds continously through the year. The mature female lays a large number of small, flask-shaped eggs, which she inserts into the tissue of the leaves, until only a little more than the crater-like tops protrude through the epidermis. The eggs are placed singly on the undersurfaces of the leaves and are scattered over the entire area. The length of the egg stage varies from five to seven days with the majority hatching in six days. The following table is an extract from breeding notes taken at various times of the year:

Table 1.—Length of Egg-Stage of Lace-Bug.

No.	Eggs laid	Eggs hatched	Incub. period	No.	Eggs laid	Eggs hatched	Incub. period
			Days				Days
1	July 5.....	July 11.....	6	7	Dec. 2.....	Dec. 8.....	6
2	July 10.....	July 15.....	5	8	Dec. 4.....	Dec. 11.....	7
3	July 20.....	July 26.....	6	9	Dec. 10.....	Dec. 16	6
4	Aug. 4.....	Aug. 10.....	6	10	Jan. 3.....	Jan. 9.....	6
5	Aug. 16.....	Aug. 22.....	6	11	Jan. 7.....	Jan. 14.....	7
6	Sept. 2.....	Sept. 7.....	5	12	Jan. 8.....	Jan. 14.... ..	6

The young nymphs are quite active at first but soon settle down to a quiet existence, feeding together in large colonies on the undersides of the leaves. Occasionally a few may be seen feeding on the upper surface of the leaves and when feeding on the weed *Solanum torvum* they feed as much on the upper as on the lower surface of the leaves. The nymphs develop quite rapidly, passing through five successive moults before attaining adult form. The period between moults is remarkably constant being in practically all cases of two days duration. The following table is a record of the moulting periods of some of the individuals reared in the laboratory:

Table 2.—The Moulting Stage of Nymphs of Lace-Bug.

No.	Date hatched	First moult	Second moult	Third moult	Fourth moult	Fifth moult	Adult
1	July 23.....	July 25.....	July 27.....	July 28.....	July 30.....	Aug. 1.....	.....
2	July 23.....	July 25.....	July 28.....	July 30.....	Aug. 1.....	Aug. 3.....	.....
3	July 23.....	July 25.....	July 27.....	July 29.....	July 31.....	Aug. 2.....	.....
4	Aug. 2.....	Aug. 4.....	Aug. 6.....	Aug. 8.....	Aug. 9.....	Aug. 11.....	.....
5	Aug. 2.....	Aug. 4.....	Aug. 5.....	Aug. 7.....	Aug. 9.....	Aug. 11.....	.....
6	Aug. 5.....	Aug. 7.....	Aug. 9.....	Aug. 11.....	Aug. 13.....	Aug. 15.....	.....
7	Oct. 4.....	Oct. 5.....	Oct. 7.....	Oct. 9.....	Oct. 11.....	Oct. 13.....	.....
8	Oct. 4.....	Oct. 6.....	Oct. 8.....	Oct. 10.....	Oct. 12.....	Oct. 14.....	.....

The time taken from the hatching of the nymph to the appearance of the adult is thus only ten days, an extremely short time, and as the females are quite prolific in their egglaying, the increase in numbers of the insect is very rapid.

Description of Stages.

The Egg.—Length .48 mm., width .22 mm., flask-shaped with the neck bent to one side. Top of egg crater-like, having a ragged border and a circular impressed area that is cross-hatched with delicate markings. This circular top is .13 mm. in diameter and acts as a lid that is pushed aside when the young nymph hatches. Egg white in color, translucent; surface smooth and shiny.

NYMPHAL STAGES.

First Stage.—Length .65 mm., width .36 mm.; body slender, general color pale yellowish dorsally, fading to white on the ventral surface. Eyes red, antennae short, and club-like at the tip.

Second Stage.—Length 1.09 mm., width .52 mm.; body oblong-ovate, general color a pale yellowish white; margins of abdomen and thorax and dorsal surface of head, thorax and abdomen armed with spiny tubercules, tubercules on dorsal surface dusky; tips of antennae and tarsi a light brown.

Third Stage.—Length 1.53 mm., width .8 mm.; similar in form to previous stage only larger, and has rudimentary wingpads; dorsal spines darker in color and regions round them dusky, forming a distinct color pattern.

Fourth Stage.—Length 1.75 mm., width 1 mm.; similar in form to previous stage only larger, body markings darker; wingpads much longer, their tips dusky-brown.

Fifth Stage.—Length 2.3 mm., width 1.2 mm.; body oblong-ovate, dorsal surface more or less flattened; general color a yellowish-grey, with a few dark brown markings. Last six segments of the abdomen provided on each side with a marginal tubercule armed with one long and several shorter spines, the abdomen apparently terminating in two of these spiny processes; first two pairs of marginal abdominal tubercules a dusky-brown. The *metanotum* provided with two large, dark-colored tubercules armed with spines, the abdomen provided with three median, dorsal tubercules similar to those on the *metanotum*; wingpads each armed with a marginal tubercule and several marginal spines. Head armed with three tubercules and two anterior marginal spines; head light in color except posterior margin which is dusky; pronotum light in color with two dusky bars near the anterior end arranged in the form of a V. *Metanotum* dark, abdomen light in color with dusky segmentation marks and dark-colored tubercules. Wingpads light colored with a dark spot on the disk, and with dusky tips. Antennae about one-third the length of body, clothed with a few short hairs, the tip somewhat club-shaped and dusky-brōwn in color. Legs fairly long and slender, terminating in chitinized claws, general color light except tarsi which are dark brown.

Adult.—This lace-bug is a delicate lace-like little insect belonging to the heteropterous family *Tingitidae*. It is one of the very few representatives of this interesting family that inhabit the Island of Porto Rico. It is about 3.5 mm. long, body dark, hood and lace-like wings grey marked with brown.

Natural Enemies.

Several predaceous insects feed on the soft-bodied nymphs of this lace-bug, among which are the Coccinelid beetles *Megilla innonata* Vauls. and *Cycloneda sanguinea* Linn., and the *Reduviid* bugs *Zelus rubidus* Lap. and Serv. and *Z. longpipes* Linn.

Control.

This insect may be effectively controlled by a soap-and-water spray, eight pounds of soap to fifty gallons of water being a good strength to use. The plants should be sprayed as soon after the appearance of the lace-bugs as possible, since it is much easier to control them then than later.

LIFE HISTORY OF HALTICA JAMAICENSIS FABR.

By R. T. Cotton, Assistant Entomologist, Insular Experiment Station.

In 1792 Fabricius described this beetle under the name of *Galleruca jamaicensis,* but a year later becoming uncertain of his species he changed the name to *G. bassiae.* In 1808 Olivier gave the name of *G. plebja* to this species, and Sturn in 1843 gave it the name of *Graptodera tarsata.* In 1875 Harold recognized *jamaicensis* as the correct name calling it *Haltica jamaicensis* Fab. and relegating the other names to synonymy.

It is recorded as occuring in Jamaica, Santo Domingo, Haiti, Porto Rico, Costa Rica, and Cuba. It apparently varies quite a little in color in different localities, but there is doubtless but one species concerned.

This beetle is the largest of the flea-beetles found in Porto Rico and at times is extremely abundant. Confining its attention chiefly to one of the common weeds, *Jussiaea leptocarpa* and two closely allied plants *J. suffruticosa* and *J. erecta,* it occasionally feeds on garden beans and conceivably might do great damage if for any reason its ordinary food supply should give out.

Both adult and larva feed very voraciously on the foliage of the *Jussiaea* plants, usually entirely stripping the plants in their immediate vicinity.

Life History.

The eggs are laid in batches of from one to thirty, sometimes side by side in a regular row, sometimes massed together one on top of the other. They are a pale buff yellow color, oblong-oval in shape

and are placed on the leaves and stems of the plant. Although sometimes concealed in folds of the buds and flower-heads they are more often in plain view, placed on the upper surface of the leaves. The adult females are very productive, one female in captivity producing eight hundred and eighty-seven eggs during a period of sixty-eight days. The average, taken from the laying record of thirty females, was five hundred and twenty eggs.

The eggs hatch in from four to six days, and the young larvae that emerge begin at once to feed upon the foliage. Growing rapidly the larva moults at the end of five days and again three days later. Growth continues rapidly for a few days, then becomes slower and slower until no further increase in size is perceptible, yet it is not until fifteen days later after the second moult that the larva descends to the soil to pupate. Five days are spent in a prepupal state and six more in the true pupal state before the adult beetle actually emerges, thus making a total of thirty-nine days from egg to adult.

Technical Description of Stages.

Adult.—A large steely blue beetle. Original description by Fabricious.

Oblonga cyanea antennis pedibusque nigris affinis C. alni at alia et minor, thorax et elytra cyanea, nitida, immaculata, abdomen obscurum. Pedis niger.

Egg.—The egg is pale yellow in color, oblong-oval in shape, and provided with an exterior covering that is usually broken in places, showing the inner shell. This exterior covering is finally reticulated and dull in appearance. The inner covering is slightly shining and is sculptured with hexagonal-shaped markings. Length 1.2–1.3 mm. Width .45–.5 mm.

Larva.—Robust, tapering gradually from the fourth abdominal segment both cepheled and caudad; general color yellowish-brown, with numerous black tubercules on each segment; head black, thoracic and anal plates black and strongly chitinized; legs black, head and body well supplied with numerous spine-like hairs. Length 14 mm., greatest width 3 mm.

The immature stages of the larva are smaller, and the tubercules closer together, giving the first-stage larva the appearance of being almost black.

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SCALE-FEEDING HABITS OF A PORTO RICAN MILIPEDE.

Rhinocricus arboreus (Saussure).

By R. T. Cotton, Assistant Entomologist, Insular Experiment Station.

While investigating the feeding-habits of some of the common millipedes of the Island, to ascertain whether or not they were injurious to truck crops, I was surprised to find that one of the species had the very interesting habit of feeding on the purple scale of citrus, *Lepidosaphes beckii*.

This millipede is a large, dark reddish-brown form about 80 mm. long. Dr. R. V. Chamberlin of the Museum of Comparative Zoology, Cambridge, Mass., has very kindly identified it for me as *Rhinocricus arboreus* (*Saussure*) and says that it is known from several other West Indian Islands, St. Thomas, St. Croix, Antigua, etc.

It was while walking through a citrus grove at Río Piedras, P. R., that my attention was attracted by seeing several specimens of this millipede, among the branches of the grape-fruit tree that was heavily infested with the purple scale. Pausing to watch them for a few minutes, I noticed that they were feeding voraciously on the scale, and smooth, clean patches on the scale-infested branches indicated where they had been at work. Transferring them to the laboratory I placed them on grape-fruit twigs that were completely covered with

scales, and in a very short time the twigs were cleaned off. Some idea of the voracity of this millipede may be gained from the fact that one specimen, by actual count, consumed two thousand scales in a period of three hours, and after a short rest continued feeding.

This species of millipede is quite abundant in this locality, and in order to satisfy my curiosity as to whether or not I could entirely clear a tree of scales by them, I captured a number of them and placed about a dozen, in each of several small grape-fruit trees that were badly infested with the purple scale. They seemed perfectly contended with their new surroundings and commenced at once to feed on the scales. At the end of two weeks the trees were perfectly clean and free from scales and the bark took on a fresh green color. At this time most of the millipedes left the trees in search of more food although one or two remained and are still in the trees, four or five months after they were introduced. Singularly enough these trees are still perfectly clean although they have had no other treatment, while other trees in the block that were sprayed with an oil emulsion, but did not have any millipedes, are again very heavily infested with scale. Although they are never likely to be of any great importance in controlling scale insects in the grove, it is interesting to note this habit of a supposedly vegetable feeding myriapod.

Although preferring the purple scale, this millipede will feed on other scales, as I have found by experiment with specimens in the laboratory. I have not observed them in the field feeding on any but the purple scale. I do not wish to leave the impression from these notes that the millipede in question feeds entirely on scales, because it does not, the scales being but a part of its diet.

In dissecting out the alimentary canals of some specimens of this millipede, I was interested to find that they were all very heavily infested with worms, which according to Dr. B. H. Ransom, "represent four different species of nematodes, none of which appear to have been described. The largest and most numerous form agree very well with the genus *Isakis* Lespés, 1856, the type species of which occurs in termites." The other three species have not as yet been placed generically.